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Mining and Metallurgical Section.

Special Meeting, November 23, 1898.

SPECIFICATIONS ON STRUCTURAL STEEL AND RAILS.

DISCUSSION.

MR. W. R. WEBSTER:—The specifications for American structural steel and rails are on the whole very satisfactory. Some, of course, are behind the times, but common practice of to-day gives a much better material than they call for. On the other hand there are specifications in which the physical and chemical requirements do not agree, or that call for an extremely high elastic limit or other results, which cannot be obtained by the ordinary methods of manufacture and testing. Specifications of this kind cause the manufacturers temporary trouble, but soon adjust themselves, either by the engineer coming out frankly and modifying them, or giving instructions modifying the point at

issue, though still adhering to his printed specification. The latter method is much to be regretted, as the specifications are very misleading, and the steel accepted under these modifications never has and never will meet the original requirements.

Our Government specifications, at first, gave the manufacturers considerable trouble, but when they found that the requirements of these specifications had to be lived up to in every particular, they were forced to improve their methods in each department, and, as a result, there has been a gradual improvement in the quality and finish of structural steel, due to more uniform methods of manufacture, the most important being the control of the finishing temperature, as more steel was formerly spoiled by being finished at too high temperature than in any other way.

The quality of steel depends (1) on its chemical composition; (2) on the treatment it receives in the course of manufacture; and we are learning year by year better to distinguish the results due to each. To-day, at some of the mills, they are getting results that were formerly considered impossible. I refer to rolling the steel into finished product, which meets all the requirements of the most rigid specifications, without stopping to make any preliminary tension test whatever. The steel is not allowed to cool from the original casting temperature until it is rolled into the finished product. This, of course, is a great saving of fuel, and increases the output. This great advance has been brought about by close observation of the methods of manufacture and the establishment of the relations between the chemical composition and the physical properties. The analysis of each heat is made while the ingots are still in the soaking-pit. The ultimate strength is estimated from its chemical composition, then the heat of steel is rolled on orders where it will apply, due allowance, of course, being made for the thickness of the finished product.

I have made a special point of the heat treatment of steel in connection with work, as the quality of the finished product depends more on it than is generally admitted or understood, and I consider that it is now the most

promising field of experiment and research. To-day we hear less of the mysterious failures of steel than ever before, as, when a failure occurs in the shop or elsewhere, examination shows that in nearly all cases the trouble has been caused by improper treatment, and indicates the necessary improvements required in shop methods to avoid a recurrence of the trouble. In order to prove this, good material has been taken and similar failures have been produced at will by the same treatment. This has brought about in many shops as great an improvement in their methods of working the steel as in its manufacture. The net result of all this is that the consumer is to-day getting a better structure than ever before.

Recent careful scientific investigations have given us valuable information of the character and properties of steel, but there yet remains the important work of showing the direct relation between the results of these investigations and the every-day processes and results obtained in our mills and shops.

There is considerable room for improvement in our ordinary methods of testing structural steel. The conditions under which tests are made should be reduced to a standard as regards the pulling speed and the relation of the width of test piece to thickness of the material. About three widths would be sufficient to cover all ordinary thicknesses, and they could be used without materially increasing the cost of the present methods of preparing test pieces. We also need some simple machine for making impact tests, as our ordinary tension tests do not give us all the information required as to the quality of the material to resist shock.

Too much importance is paid to the quench bends. In some cases the cold bends have been entirely omitted and the quench bends considered a reliable test as showing the quality of the material. Now, this is all wrong, as soft steel which has been finished at too high temperature, and thus rendered brittle so that it will not stand the ordinary cold bends, may be restored by the heating, and the carbon being so low that the subsequent quenching does not harden this class of material, it then bends 180° flat on itself. Material

accepted under these conditions has failed under subsequent shop work. Such material would have been rejected at the mills had the ordinary cold bends been made.

In the following I quote freely from my recent paper before the American Institute of Mining Engineers.

Regarding the specifications for material on export orders, it is a very different matter, as the engineers are at a distance and there is not always time to refer questions for their decision. In cases where the chemical requirements do not agree with the physical requirements specified, the inspector is sometimes forced to reject material that he knows from his experience is all right. It may give better physical tests than were called for but not conform to the chemical requirements in the particular specifications in question, though it would meet both the physical and chemical requirements of our leading engineers and railway companies in this country. Some of these foreign specifications are so worded, and the requirements are such, that it is not safe for an American manufacturer to bid on the orders. This may be due in part to their not understanding all of the conditions under which the tests are to be made. In other cases it seems as though modifications must have been made on previous orders, either in the chemical requirements or physical tests called for, as no steel was ever made that would meet all the requirements of chemical and physical tests in some such specifications.

Many export orders for rails call for phosphorus not over ·06 per cent., while the sulphur is allowed a much higher limit, or not specified at all. This low phosphorus cuts out several of our largest steel works, whose material will meet all of the physical tests called for, being low in sulphur and under ·10 per cent. phosphorus, and giving entire satisfaction to our leading engineers and railroad companies. The foreign manufacturers of basic Bessemer steel and low-phosphorus acid Bessemer steel are working the low-phosphorus clause for all it is worth, just as our manufacturers would do under similar circumstances; but we, as engineers, want to know if there is any good reason for this distinction, which is made on account of local conditions, and if the high sul-

phur is not as undesirable as the phosphorus would be up to the limit of ·10 per cent. usually allowed in this country?

This is a matter that should be thoroughly discussed, and on which opinions should be secured from our leading engineers; for it is of no use for the manufacturers to give their opinion unsupported by the experience of users of their rails. It is just here that the effect of the different elements plays an important part. Our manufacturers know from experience that as their phosphorus is a little higher than the limit of ·06 per cent. referred to, they must keep the other elements inside of given limits to produce the best results in the finished rails. This is done successfully, and a rail is produced that will meet the requirements of the drop-test and give satisfaction in use. I do not wish to be understood as advocating high phosphorus, but my position is, that rails which will meet all of the varying conditions in this country will meet all that is required of them when put in use in other countries. If one examines the methods of manufacture of rails in this country and those in other countries, then visits the countries where our rails are being introduced, and gets accurate information as to the service they are giving, he will be convinced that there is a great future for America in the export business in rails.

The conditions with regard to the material for bridges are about the same. Foreign specifications, in many cases, provide that only acid open-hearth steel can be used. This has already prevented our bridge-builders from bidding upon thousands of tons of bridge-work, although in some cases they have accepted the requirement of acid open-hearth steel, and have taken the orders. In other cases they have explained that our Government is using the basic open-hearth steel; that in the manufacture of it the works here start with an iron very much lower in phosphorus than is ordinarily used, and that the resulting steel is much more uniform. This has had a great deal of weight, and the use of basic steel has been allowed in some cases. In other cases new specifications have been adopted after investigation in accordance with the best American practice, which allows the use of either basic or acid open-hearth steel. I

refer to this matter at length, as it is of the greatest importance to our engineers and manufacturers, as well as to all others who wish to see our export trade developed. It is of the greatest importance to establish the quality of American material abroad, and to have on record all facts regarding the same both from the engineer's side and the manufacturer's.

In September last, I read a short paper before the American Branch of the International Association for Testing Materials, calling attention to the manner in which our manufacturers are handicapped by specifications for export material, and I am pleased to state that they have decided to appoint a special committee to investigate and report on the use of basic steel for bridges, and the use of steel for rails, containing up to .10 per cent. phosphorus. I trust that this Institute will be represented on that Committee as it has done such good work in the past on iron and steel. You are all, no doubt, more or less familiar with the work of the International Association for Testing of Materials; but Mr. Henning, one of the council, who is present, has kindly consented to explain in detail the objects of the Association and point out wherein the Mining and Metallurgical Section of the Franklin Institute can co-operate with them in their work.

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MR. GUS C. HENNING (New York):—As long as eighteen years ago it was recognized in Germany that too little attention was paid on the one hand to proper qualities of materials for specified purposes, and on the other to the methods used for determining these qualities, which were so various and frequently vague, that prominent investigators began to compare notes for the purpose of determining upon some method by which improvements might be effected in these matters.

Hence eminent metallurgists and experimenters, with the late Prof. J. Bauschinger at their head, decided to meet in conference and present their individual views on the subjects to be discussed.

It was at once decided that there should be no constraint or compulsory action, and that all deliberations were to be embodied in resolutions taken and modified from time to

time as opportunity, metallurgical change and the then knowledge required or made possible.

A few conferences showed the existence of a mass of incongruous methods and such a variety of constants for each kind of material that it became necessary to adopt or suggest standard shapes of test pieces and also methods of testing.

Tests had been made in such a variety of ways that any one variety of steel, for instance, apparently showed the most ridiculous differences in strength, elongation and other properties. Upon making tests on a uniform basis, it was found that there were still differences, some of which could and some of which could not be explained.

In this manner, recommendations for methods of testing and shapes of test pieces were made for tension, crushing, bending, impact, torsion and repetitive tests, so that at the present day results have become generally comparable, and the value of results stated is generally known.

Not only were the metals considered at these conferences, but cements, stone, paper, etc., etc., were discussed and their study referred to commissions for report at later meetings.

At the present time, however, our knowledge of the subject is so incomplete that no less than twenty-nine different problems have again been submitted to commissions for further inquiry.

During these conferences it had become apparent that it was not sufficient to study and discuss this subject from the points of view obtaining in one country, but that those existing elsewhere were equally important, especially when considering the demands and requirements of trade between various countries.

Numerous nationalities had already taken part in these conferences, until finally, in 1893, the United States was also represented, as your narrator was sent to Vienna to take part in the deliberations as representative of the American Society of Mechanical Engineers, as which he has since acted at Zurich in 1895 and at Stockholm in 1897. At Zurich the United States Government was represented

by an army engineer officer, while at Stockholm both army and navy were represented.

At Zurich the French Government took part officially for the first time, and at Stockholm England also had representatives. Now the International Association for Testing Materials, which had crystallized at Zurich out of the previous conferences, numbers more than 1,500 members, and is growing rapidly. The American Section already counts eighty-five members, among whom are some of the most prominent steel works, and a number of the best known cement experts.

Among the twenty-nine problems which have been remitted to the sub-commission for further study and report, by the Stockholm Congress, are three which are of especial interest to sidero-metallurgists, and are at the same time of considerable commercial interest. Before mentioning these in detail, I desire to explain that it had become apparent to European engineers that there were other fields in which the Association could profitably work, besides the more abstract or strictly technical subjects of methods, standards, etc., etc., which had theretofore occupied its entire attention. Moreover the result achieved had been so satisfactory and the recommendations had been so generally adopted, that it seemed possible to make the deliberations of immediate practical value.

It had been felt that the use of materials for specific purposes was so heterogeneous and indiscriminate and the specifications under which they were to be made and inspected, so manifold, in many ways original, and showing the idiosyncrasies of individual engineers and corporations, that it was deemed the proper time to take up these subjects with the view of introducing system and method into this apparent chaos.

For this purpose, and with this in view, the following problems were proposed and have now been submitted to commissions for consideration, investigation and report:

(1) On the basis of existing specifications, ways and means are to be suggested for introducing international rules for testing and inspecting materials.

(2) Proposition to determine methods of determining the homogeneity of iron and steel, applicable for purposes of and at the time of inspection.

(3) Collection of information for the purposes of establishing standard piece-tests for the purpose of properly and rapidly inspecting lots of finished material, such as rails, axles, ties, springs, cast and wrought pipes and other finished parts of structures.

The chaos of specifications for material had already necessitated the arrangement of all iron materials into groups or classes, and this, as the processes of making the materials were few and very similar, did not offer many difficulties. The processes used in other countries had not been considered, as there was no person present interested in them, to present their differences and suggest the advisability of broadening the field of study so as to cover all processes used in any country. As the English had never taken any part in these deliberations, they had not become cognizant of the peculiarities of their own requirements and specifications, and have not even adopted approximately uniform methods of tests and shapes and sizes of test pieces, so that at the present time an English report of tests is the least valuable of any, because not made on a basis and standard, well known and clearly understood in every case, without special inquiry.

The first of the problems stated, now before the International Society, shows clearly that it is generally recognized that there is a multitude of varying specifications and rules for testing and inspecting materials, and that it is considered advisable to introduce some sort of uniformity. The object is, of course, to facilitate labors of the works and of the engineers, as well as to open the way to a clear understanding by all parties interested, of the intents and purposes of the specifications and their proper interpretation. Nothing is more annoying to the manufacturer and the user than misunderstandings in regard to the intent and meaning of some part of the contract after the same has been signed. Unfortunately, these details of contracts are rarely discussed in advance; and, in fact, in most

cases this would not be possible, because it is common practice to contract to furnish a lot of steel by the hundred or thousand tons for "structural purposes, rails, ship-plates, etc.," without any statements as to quality, because it is assumed that this is a matter for easy later adjustment. When the time for the latter arrives, if, indeed, it is not left until the material is actually ready for delivery, then the trouble begins. If, however, a set of standard specifications were formulated, the difficulties would readily be eliminated, if prepared on a sufficiently broad basis, because the basis at least would in every case be well known.

At the present time it is recognized that there is such a general exchange of material between distant countries that it no longer suffices to prepare specifications which will answer either for Europe or for the United States alone.

The United States buy steel and iron in large quantities from Sweden, England and Germany. On the other hand, these same countries buy larger and larger quantities of materials from the United States.

However, the materials made in the United States are made from different crude materials and by methods differing from those used in other countries, and while the chemical compositions vary considerably, actual use of them on a large scale and experience under most varying and trying conditions have demonstrated their uniformly good and satisfactory qualities. Hence, while we know that American materials answer every purpose, they do not apparently comply with foreign specifications. Here the American national character has again made itself felt and in a most pronounced manner. It was found that our materials would produce a finished product which is not that fulfilling old specifications; nevertheless it was tried and in a short time was found to be satisfactory for many purposes and in many ways. This gave encouragement to use it on a larger scale, with similarly satisfactory results.

These results of practical experience were laid before American engineers, and specifications were at once modified to suit these new conditions, replacing the old by something better. In Europe this would be a very difficult and

tedious procedure. If Americans desire to make any impression on conservative elements, we must submit all our facts and evidence in such manner and by such responsible and trustworthy individuals or organizations that credence will be given them wherever presented.

We now know that our materials answer every purpose, and, although containing what were formerly considered impurities (and are now known to be almost necessary admixtures), in this respect failing to meet some American and nearly all European specifications, fully comply with the requirements of actual use, and hence should be permissible in best construction.

It now depends upon proper and authoritative demonstration and elucidation of these facts, by careful collation of practical experience and tests under the direction of such reputable and well-known Institutions as the Franklin Institute of Philadelphia, to take up the subject in order to be able to present overwhelming array of facts obtained from practical experience, sifted and arranged in proper manner, with documentary evidence.

Such array of proofs presented to the International Association for Testing Materials would at once reach all of the authorities interested in the subject and would accentuate the necessity for revision of specifications for material with a proper regard to actual advanced conditions of the American steel industry.

It seems to me that no one would find a more prompt response in regard to collecting sets of specifications and reports of experience with material than the Franklin Institute. Hence, it would in my opinion, be a wise move for the Institute to enter upon a field of activity in which it would render immediate practical service in the interest of our most prominent industries. Co-operation of the Franklin Institute with the International Association for Testing Materials would no doubt advance the interests of both and lead to results practically valuable; it lies directly in the sphere of action laid down in the charter, and will have a far-reaching and beneficial effect in Pennsylvania, which is so largely dependent for its welfare upon the advancement

and success of its metallurgical establishments, than which there are no more important in the world.

MR. JAMES CHRISTIE:—Mr. Webster's paper is a plea for some approach to international uniformity in specifications for steel. It is of especial interest now, when the manufacturers of Europe and America are competing in a common market for the trade of the world, and the interest manifested here and abroad in the International Association for Testing Materials indicates a desire to view the subject from some rational basis. So long as basic process steel is so prevalent in Germany and at the same time held under such a ban of suspicion in England, there is bound to be considerable divergence in specifications, and it affords engineers an opportunity to formulate demands favorable to the home producer. The interest of the purchaser being to get the best material for the price offered, it is our interest to convince him that the specifications we are able and willing to conform to, afford him sufficient protection in judging the quality of the material, and it is believed that the specifications of the leading railroads of the United States are sufficiently strict and exacting to meet any reasonable demand.

Those who have had an opportunity to observe the development of steel manufacture in this country will concede that there is much less friction between manufacturers and inspectors now than formerly, and further, that the average standard of quality has been decidedly improved. So long as rails are made from Bessemer steel by acid process we can hardly expect to fully meet the foreign specifications which Mr. Webster criticises, demanding phosphorus below ·06 per cent. Nor do I know that there is any valid reason why double that percentage is alone sufficient cause for rejection if the other constituents are satisfactory. Perhaps they are right in allowing a much higher limit for sulfur than for phosphorus for material that has not to be re-heated subsequently, as there appears to be no evidence of injurious effects following.

The rapid extension of the basic process in American open-hearth practice and its almost universal acceptance in

our most important structures, coupled with the fact that the material but recently bore a stigma, remaining from early defects in the process and from the misapplication of materials, and hence was subjected to the most rigid inspection and scrutiny, indicate that this steel gives satisfaction and the process is thoroughly established. If, as we are told, the same condition does not exist in British manufacture, the fault must lie in the raw material used.

If the objections urged are only lingering prejudices, they will not last long, and the American manufacturer has only to maintain the standard of quality accepted at home and prove the reliability of his product to command the confidence and patronage of the foreign consumer.

MR. H. V. WILLE:—I cannot too strongly endorse Mr. Webster's remarks on the heat treatment of steel, especially those in reference to quench and ordinary bending test. A sample of steel recently came under my observation which, when judged by the tensile strength, reduction of area, elongation and chemical analysis, would be regarded as the highest grade of material, and, in fact, it passed two inspections on such tests. Notwithstanding the results of these tests, the plate cracked in numerous places between hole when an effort was made to roll to a 60-inch ring. A test was now cut from the plate, and failed, as you will see by this sample, on ordinary cold bend; but a second test cut from the same portion of the plate, when heated to dull cherry and quenched in water, bent flat without signs of distress, proving that a good plate of steel was injured by finishing at an improper temperature. The quality of the steel can be judged by the following tests:

Tensile strength, pounds per square inch	= 59200
Elongation, per cent. 8 inch section	= 28
Reduction of area, per cent.	= 60·2
Carbon	·24
Manganese	·39
Phosphorus	·012
Sulphur	·020
Silicon	·020
Copper	trace

MR. A. A. STEVENSON, Burnham, Mifflin County, Pa:—I have read the paper on "Specifications on Structural Steel and Rails" with interest. I have had very little time to devote to the subject, but some of the following facts gathered from my own experience may be interesting to you.

You state that "the quality of steel depends (1) on its chemical composition; (2) on the treatment it received in the course of manufacture." I would go a step further, and say that, in my opinion, as far as open-hearth steel is concerned, the physical results, to a certain extent, depend on manipulation of the bath in the furnace.

Concerning the relations between the chemical composition and physical results, I must say I have been somewhat surprised to find how close this relation is. The point in question has been brought out strongly in test work we have recently done on some tires made for a foreign government to a rather difficult specification.

I heartily agree with the effort to have the conditions under which tests are made reduced, as far as possible, to a standard. In my own experience, I have found a great many tests that were practically valueless for comparative purposes on account of unknown or varying conditions.

I think it is desirable not only to have dimensions of test piece and pulling speed standard, but also important to have a record of the period elapsing between the time product is finished and tests are made. That a change takes place in steel after finishing, which materially affects the physical results, cannot be questioned.

In connection with above, the following figures may be interesting. Test pieces were all cut from tires and duplicate tests, as far as possible, from the same part of the tire, as, owing to section of a tire and process of manufacture, tests from different parts of same section show a variation.

Test.	Dimen.	Elast. Limit.	Ult. Strength.	Elong. Per Cent.	Reduct. Per Cent.	Remarks.
311160 A2	2 x ·500	53490	107460	15·	19·20	Pulled within 3 days after tire was made
311160 A2	2 x ·500	56037	108700	16·30	24·30	Ten days later.
311283 A2	2 x ·500	50940	99590	14·00	22·20	Pulled within 3 days after tire was made
311283 A2	2 x ·500	53000	103464	18·00	27·40	Ten days later.
311356 A2	2 x ·500	56037	111050	10·00	12·37	Pulled within 3 days after tire was made
311356 A2	2 x ·500	61130	111410	15·00	21·50	Ten days later.
319619 A2	2 x ·798	70370	121250	11·00	14·01	Pulled 5 days after tire was made.
319619 A2	2 x ·798	71980	121970	14·00	17·89	Seven days later.
318932 A2	2 x ·798	65080	121470	11·50	13·55	Seven days after tire was made.
318932 A2	2 x ·798	64400	121160	13·00	16·30	Fourteen days later.

Tests were all pulled at the same speed.

MR. JOHN STERLING DEANS, Chief Engineer Phœnix Bridge Company, Phœnixville, Pa.:—We are in entire sympathy with the effort to secure uniformity in the specifications of steel—such uniformity would be equally valuable to the engineer and manufacturer.

DR. CHAS. B. DUDLEY, Altoona, Pa.:—I am obliged for the outline of Mr. Wm. R. Webster's remarks before the Mining and Metallurgical Section on "Specifications on Structural Steel and Rails," copy of which reached me a day or two ago. I am sorry that I cannot promise to be present at the meeting.

I will only say, as voicing my experience now for some twenty years, that in my judgment improperly made specifications are the cause of more difficulty in the use of steel than any other single cause. On the other hand, properly made specifications are an absolute essential to the successful use of steel in large quantities. If I could be with you I should be glad to expand on this point at length.

MR. PAUL KREUZPOINTNER (Altoona, Pa.):—Mr. Webster's paper might be divided into three parts, each of which is important enough to form the topic for a separate discussion. The mill and heat treatment of steel of whatever kind is such an exceedingly complicated subject that it takes a large and varied experience, supplemented by

much patient experimenting and examining, in order to be able to grasp the importance of the subject fully. In my paper, "Riddles Wrought in Iron and Steel," which I will have the honor to read before the Mining and Metallurgical Section of the Franklin Institute, I will return again to this subject.

Aside from this topic, Mr. Webster discusses the value of present specifications issued by consumers at home and abroad. The same remedy for possible defects in that direction applies to both these topics, namely, uniformity of methods of testing and analyzing. A satisfactory standard of quality cannot well be established before the establishment of uniformity in the methods of ascertaining the uniformity of such a standard. Structural steel stands a great deal of torture and maltreatment, more than the average consumer is aware of sometimes, as a consequence of which many a consumer swears to the unquestionable value of his specifications, or method of testing, or both, simply because his material or structure has not yet broken down. The consumer does not always seem to comprehend the fact that, because a material is safe, it is not also the most economical. Of course, large consumers will soon find out what they want and need, but there are comparatively few who have the necessary every-day experience and means to arrive at the proper conclusions. Thus uniform methods of testing would soon help the law of the survival of the fittest to weed out undesirable features in home and foreign specifications, but not before, because then not only the present quality of a structural material will be established, but largely also its economic value as far as durability is concerned. An engineer now specifies a given quality; this material is tested according to one of different methods, and is approved. But neither the specifications nor the method, standing alone and for themselves, is a guaranty that the least economical amount of material nor the most suitable quality has been used, and the question might be raised in such a case whether the final owner of the structure was not compelled to pay for more material than was necessary, or paid a higher price for its quality than was necessary; or paid

for an inferior quality—a quality verging constantly on the edge of a breakdown, though unknown to all parties concerned. Uniform methods of testing have a tendency to bring the competitive qualities of materials to the surface, as it were, and this will naturally be followed by uniform specifications. Considered, therefore, from the standpoint of natural evolution, agitation for uniform methods, and the presentation of results of long established methods, having produced both economy and safety, should precede agitation for uniform specifications, because if we urge necessity of uniform, or any given specification, we should be able and prepared to bring positive or negative proof that such specification will give the best results. We cannot very well give such proof as long as a score of people raise their hands and each one asserts he is in the exclusive possession of the right and only method to furnish the desired proof. Next in importance is the question how much methods of testing may differ and yet producing practically uniform results. In commercial, testing and all scientific testing and analyzing serves only to give greater value and usefulness to commercial testing, the latter being the crucial test for the practical value of scientific work, such a difference in details is permissible, since the properties of metals vary more or less within safe limits and a certain amount of elasticity in methods of testing, as well as of the requirements of specifications, is not only desirable but necessary.

Stated Meeting, November 9, and Special Meeting November 23, 1898.

A STUDY OF THE MICRO-STRUCTURE OF BRONZES.

By A. E. Outerbridge, Jr.

At the stated meeting of the Mining and Metallurgical Section of this Institute held in May last, Mr. Guilliam H. Clamer read a very interesting paper on the "Micro-Structure of Bearing Metals," which was embellished with a large number of excellent photo-micrographs. In the discussion which followed, I stated that I made some microscopic examinations of standard silver alloys (900 parts of silver, 100 parts of copper) twenty years ago, with the view of endeavoring to obtain light upon the phenomenon known as "segregation," but met with little success.

The science of microscopic metallography was, at that time, in its infancy, but since then it has attained a high degree of development in the hands of eminent investigators in Europe and in this country. Among these are M. F. Osmond, Professor Le Chatelier, Dr. Charpy and others, of Paris; Prof. A. Martens, of Charlottenburg; Dr. Wedding, of Berlin; Mr. J. E. Stead, F.C.S., of Middlesborough, England; Mr. Albert Sauveur, of Boston, besides many others. The literature upon this subject, chiefly found scattered through the reports of various technical societies during the past ten or fifteen years, is very extensive and most valuable to the student.

A few years ago I began to study the micro-structure of cast iron, and I encountered certain difficulties which, so far as I know, have not been described or satisfactorily explained as yet. Cast iron is, as you all know, a complex alloy, or, perhaps, to speak more accurately, it may be described as a metal containing a number of dissimilar elements, such as carbon, silicon, sulphur, phosphorus, manganese and traces of rarer metals and metalloids, partly united in chemical union with iron, as in the case of "combined" carbon, and partly held mechanically diffused

through the mass, as in the case of "free" carbon, which is so loosely held in the spaces between the crystals that it may be readily brushed out from a freshly fractured surface.

Two important sources of error in observation or deduction presented themselves in this study. One of these relates mainly to the remarkable influence that the rate of cooling of a mass of molten cast iron exerts upon the molecular structure of the metal. The other has to do with changes in appearance under the microscope of polished and etched specimens caused by variations in strength of acid, length of time of immersion, etc.

With respect to the first observation, I found that different portions of one specimen revealed differences in molecular structure, so that a photo-micrograph taken from the center of a piece might present quite a different appearance from that of a similar picture taken from a point nearer the edge of the specimen. This difference was apparent even in sections of quite small castings, and it may safely be asserted that cast iron differs radically in this respect from cast steel, which is more nearly homogeneous throughout the mass.

With respect to the second point, I found that a change in strength of acid, or in the time of etching, sometimes produced so great a change in the appearance of the surface that misleading conclusions might readily be drawn therefrom. In order to study this matter carefully, I etched a small piece of gray iron and also a piece of white iron taken from the same casting, and studied the structures microscopically, then repolished and re-etched the pieces many times. I have several photo-micrographs taken from these specimens, and the apparent differences in structure are greater than would seem to be properly attributable to the known variations in treatment. Further comment upon this matter must, however, be deferred for the present; reference is made thereto in this place merely for the purpose of explaining the reasons that led me to make the examinations now about to be described, which are here presented tentatively, and in an incomplete stage, for the purpose of inviting discussion and criticism from those present, some

of whom, I know, have gone more deeply than I have been able to do into the study of the micro-structure of bronzes.

Recently I have been engaged in examining in various ways a large number of specimens of bronze metal cut from small castings, with the view of endeavoring to obtain denser or finer grained and more homogeneous metal. The specimens (about ninety in number) were of two sizes from each melt; one was a flat disk about 1½ inches diameter, ¼ inch thick, the other was a cylindrical piece about ⅜ inch diameter and ½ inch thick. A number of these pieces were polished on one face, etched in weak muriatic acid, and others were etched in nitric acid, using generally one part of acid to nine parts of distilled water for microscopic examination. While I was engaged in this preliminary work, a photographer of this city, Mr. Fred. D. Maisch, called to show me some photo-micrographs of pathological specimens and of sections of steel that he had made, stating that he desired to make a specialty of such work, although disclaiming any expert knowledge of metallurgy. Being pleased with his exhibit, and wishing to encourage him, I gave him a few of the unpolished bronze disks, numbered for identification, without any information as to the character of the metal or the object of the investigation, neither did I make any suggestion as to the polishing or etching process; I merely stipulated that all of the specimens should be prepared for photographing in precisely the same way.

The results produced were satisfactory to me, and the differences in micro-structure as shown by the photographs accorded with my expectation, knowing, as I did, the difference in treatment of the metals in the crucible.

Then Mr. Maisch expressed a desire to make some other photo-micrographs if I would furnish the specimens and propose a scheme of study.

I told him of my former observations with cast iron, and suggested that he should re-etch one of the bronze pieces which he had already photographed for me, then make a new negative from the same portion of the specimen, noting the time of immersion, strength of acid, etc.; and if he ob-

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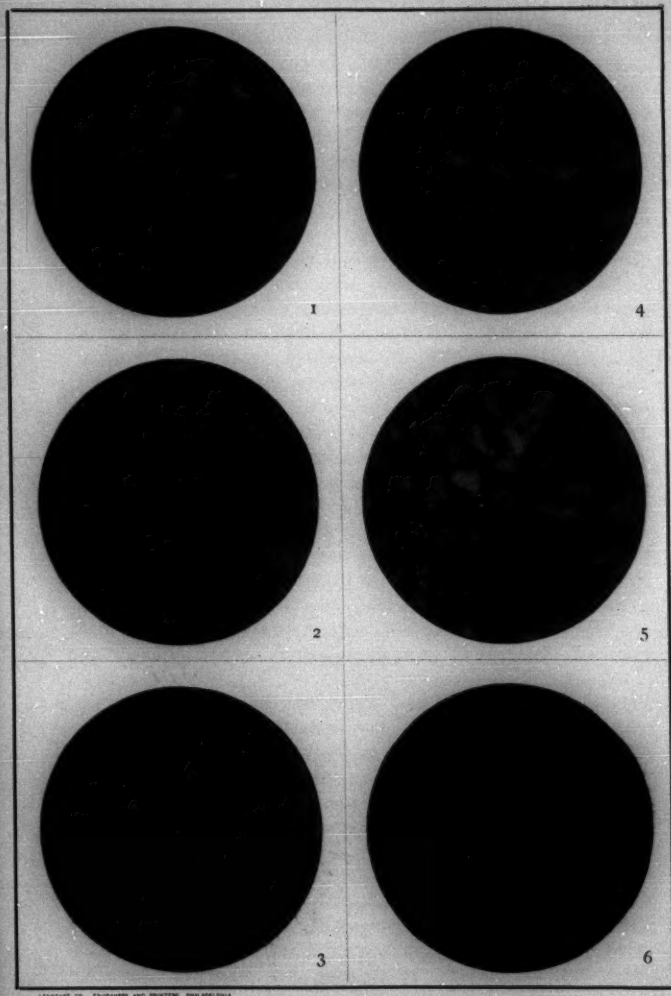
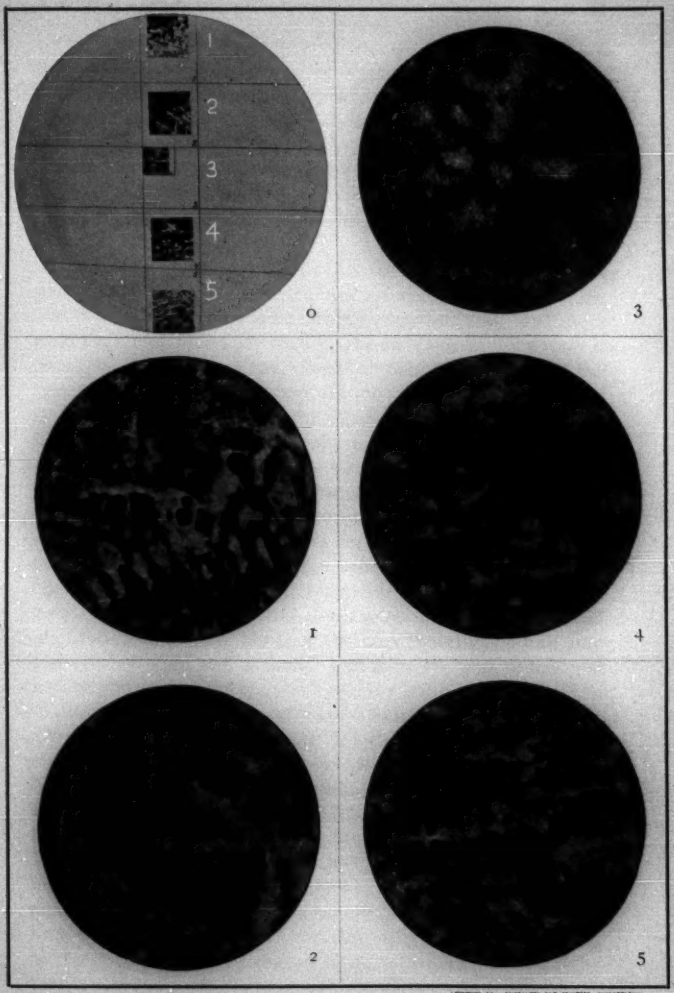


LEVYTYPE CO., ENGRAVERS AND PRINTERS, PHILADELPHIA.

PLATE NO. 1.—FIRST SERIES.

Successive etchings. Cent, etched as long as comp. experiment. Magnification 70 x.



LEVYTYPE CO., ENGRAVERS AND PRINTERS, PHILADELPHIA.

PLATE NO. 2.—SECOND SERIES.

Completed experiment. Photographs numbered as in diagram. Magnification 70 x

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served any decided change in appearance in the photograph to repeat this operation two or three times. This, h has done, making six separate exposures upon the same spot, after six separate etchings, varying the length of time of immersion and strength of acid. Mr. Maisch has also made lantern slides from these negatives, so that you can see the process of development of the structure very clearly. (See *Figs. 1, 2, 3, 4, 5* of the first series, and *No. 3* of the second series.)

The disk selected for this purpose showed in the first photograph certain characteristic groupings of dark bands, which I believe to be the so-called "eutectic alloy," and these markings can be easily recognized in each picture, but it can also be observed that considerable modification in the general appearance has been produced by the difference of treatment. If it were not for this fortunate means of identification of the specimen, I think that an observer might be pardoned if he should imagine that the photographs were made from different specimens.

While I am not at liberty to give the exact composition of this metal, which was made for commercial purposes, I may say that all of the specimens under estimation were similar in character, and they may be described in general terms as 10 per cent. alloy; that is, copper-bronze containing from 7 to 10 per cent. of tin, and usually a small percentage of zinc and a small quantity of lead added just before pouring.

In the second series of experiments two parallel lines about $\frac{1}{4}$ of an inch apart were drawn across the face of the etched specimen, the space between the lines was then divided into five squares; photo-micrographs numbered 1, 2, 3, 4, 5, corresponding with the section numbers, were then taken, as shown in the diagram (*Fig. 0*). Pictures 1 and 5 show portions of the disk at the extreme edge, while numbers 2, 3 and 4 were taken from near the center of the squares. The actual size of each spot photographed was less than $\frac{1}{16}$ of an inch, and the negatives are $3\frac{1}{2} \times 4\frac{1}{2}$ inches. The half-tone engravings are 2 inches in diameter, and represent sections from each negative.

The dark bands in these photographs are, in reality, sharply defined lines when examined under the microscope. By focusing very carefully it was discovered that these portions are in relief, and when a strong side light is cast upon the specimens it was found that quite perceptible shadows were cast; this is more noticeable in the deeply etched specimens.

I think it can be observed in the photo-micrographs that the bands are more numerous, and more closely knitted together, near the edges of the disk, than they are towards the center, and I regard this as an evidence of liquation or segregation of the eutectic alloy towards the outer portion of the casting. In other words, the fusing point of the eutectic alloy being lower than that of the mass, this alloy is driven or distilled out from the hotter portion of the metal when cast.

Dr. Charpy, in his "Microscopic Study of Metallic Alloys," says, in relation to copper-tin alloys, in which the copper largely predominates: "It was found that the rate of cooling had a marked influence upon the proportion of the eutectic alloy present in the metal.

"In quickly cooled alloys the eutectic mixture may even disappear almost completely, notwithstanding the presence of some 7 or 8 per cent. of tin, while in slowly cooled alloys, containing only 2 or 3 per cent. of tin, a certain amount of the eutectic alloy is readily discernible." Tests which I have made seem to fully corroborate Dr. Charpy's statement regarding the effect of rapid cooling of an alloy containing approximately 7 per cent. of tin.

The illustration No. 6 in Plate No. 1 shows a photo-micrograph of a bronze cent (copper, 95 per cent.; tin, 3 per cent.; zinc, 2 per cent.). The design upon one face of the coin was obliterated by filing the metal to a flat surface, and the disk was then polished and etched. It will be observed that the molecular structure is very different from that of the other bronze specimens which have not been subjected to pressure under the rolls and coining press. The crystals are much finer and the metal is apparently more homogeneous, for there is an absence of the irregular bands

of the eutectic alloy so conspicuous in all of the cast bronze specimens.

This is, perhaps, partly owing to the fact that coin ingots are always cast in iron molds and the metal is thus suddenly solidified, while all of the other specimens were cast in sand molds. This observation may have practical value.

The conclusions to be drawn from these investigations, assuming the premises to be correct, may be summed up as follows:

(1) Variations in treatment of specimens cause variations in the results, which may be misleading, and it would, therefore, seem to be desirable that some uniform system should be adopted by all investigators in this field.

(2) The rate of cooling of a mass of metal affects the micro-structure so that two specimens from the same ladle of metal, one taken from a small casting quickly cooled, the other from a larger casting slowly cooled; or two micro-photographs taken from different portions of the same specimen may show variations in micro-structure that may lead to error.

It is desirable, therefore, that some uniform size of specimens should be selected by micro-metallurgists as a standard with which to make comparisons.

In conclusion I wish to say that I am indebted to Mr. Maisch for the careful way in which he has carried out my suggestion.

Description of Plates. First Series.—(1) Plunged into strong nitric acid three times, two seconds each time, washing in liberal quantities of water after each immersion.

(2) Etched five minutes longer in 10 per cent. nitric acid.

(3) Etched ten minutes longer in 10 per cent. nitric acid.

(4) Etched fifteen minutes longer in 10 per cent. nitric acid.

(5) Etched thirty minutes longer in 10 per cent. nitric acid.

(6) Etched one hour forty-five minutes longer in 10 per cent. nitric acid, or two hours forty-five minutes, all told, in 10 per cent. nitric acid.

Nos. 1, 2, 3, 4, 5 of the Second Series were submitted to

same treatment as the 6th of the first series, which is described in the text. It represents the coin.

DISCUSSION.

MR. PAUL KREUZPOINTNER [Altoona, Pa]:—I regret very much not to be able to attend the meeting of Wednesday, the 23d inst. Nor does pressure of business and short space of time allow me to write any extended and satisfactory discussion. I am glad Mr. Outerbridge has raised the points to be discussed, since the subject under discussion is a very timely one. There appears, as Mr. Outerbridge points out, to be considerable vagueness and uncertainty of mind prevailing as to what the microscope is really good for in metallurgy. Moreover, there seems to be an entire absence among those who do use the microscope in that direction, of an understanding of the imperative need for uniformity of methods for the purpose of making microscopic examinations of metals. That the microscope can be made a valuable and very useful auxiliary to the chemical and physical laboratory of steel works, foundries and large consumers of metals there is no longer any doubt. How to make this new auxiliary most practically useful is a matter of time and understanding how to use it and when to use it. But it will never attain its full usefulness unless the advocates of the use of the microscope for metallurgical purposes bestir themselves and join hands with the committee appointed by the International Association for the Unification of Methods of Testing, to agree on some practical method for making microscopic examinations of metals. This is just as necessary as the need of uniformity of methods in the chemical laboratory and the physical testing room. The manner of preparing specimens, the kind of acid used, the strength of the etching fluid and time of immersion for etching, are all factors which, singly or collectively, influence the final results of the microscopic examinations of metals. Hence, without A, B, C and D use uniform methods their work is not comparable, and may even become misleading. Or, if one of them is right and the others faulty, which one is right. and who will decide who is right? Let a controversy arise

between producer and consumer, the operation of dispute to be settled by a microscopic examination of a given metal. If an expert is called on in the matter, then the contending parties are interested to know what standard structure of quality the expert bases his decision on and how he arrived at concluding this to be a suitable standard. Imagine several experts are called on, as is sometimes done in chemical analysis or physical testing, and each one reaches another decision, due simply to each one following a different method. The writer knows already of a case where the microscope was to decide the commercial value of a material, but it did not; not because the microscope was not the proper means, but because there were no means of comparing results.

MR. G. H. CLAMER (Chemist to the Ajax Metal Company):—I wish to corroborate the statements made by Mr. Outerbridge regarding the different structures observed by him in his study of bronzes by varying the conditions of etching, etc., and also the different structures observed in the various parts of the same bronze castings.

The alloy of copper and tin is one which is especially subject to segregation, and the appearance of the so-called tin stains or tin spots have long menaced the skill of foundrymen. These tin stains are nothing more than the liquated alloy, containing a high percentage of tin, and are very frequently seen on the fracture or on the polished surface of bronze castings, without the aid of the microscope.

The difference in the structural appearance of pieces of bronze examined by Mr. Outerbridge are undoubtedly due to phenomena of liquation which exhibits itself in varying degrees in most alloys. The so-called constant or chemical alloys being alone exempt from this disintegration.

The segregation of the copper and tin or bronze alloy has been carefully studied by many prominent scientists, notably Riche and Thurston, who studied the specific gravity and expansion and contraction of some fifty different atomic combinations of these two metals, with the result that when the alloy $SnCu_3$ was reached, it possessed the maximum specific gravity (8·91 according to Riche and

8·97 according to Thurston) together with the maximum contraction. Copper, according to Thurston, having a specific gravity of 8·791, and tin 7·293, it will be seen that the alloy $SnCu_3$ has a specific gravity greater than pure copper; this is also true of all alloys between 22 and 38·29 per cent. of tin. Below 22 per cent. of tin and above 38·29 per cent. the alloy—as would naturally be expected—becomes specifically lighter as it reaches pure tin.

The alloy showing the greatest specific gravity, together with the greatest contraction when this atomic proportion $SnCu_3$ has been reached, goes to prove the existence of a chemical combination in these relative proportions. The existence of such a combination seems also to be proven by the microscopic researches of Charpy and others, while recent investigations, by John E. Stead, of alloys containing a large excess of tin point to such combinations as $SnCu$, $SnCu_2$, $SnCu_3$ and $SnCu_4$. Crystals having these formulæ are claimed to have been isolated by Stead in alloys successively increasing in copper content. He used dilute nitric acid, which dissolved the remaining part of the alloy, leaving crystals having these definite compositions coated with hydrated meta-stannic acid. This was easily removed by dilute hydrochloric acid, and then upon examination the crystals were found to be lustrous, sharp and apparently in the form of square prisms.

According to earlier investigation, Kunzel claims that all alloys containing over 95 per cent. copper are constant, as is also the alloy of 17·7 per cent. tin and 82·3 per cent. copper, or ($Cu_{17}Sn_2$). Riche also found in this alloy but little liquation, and claims the alloy $SnCu_4$ to be constant as well as $SnCu_3$.

From the foregoing data it will be seen how diversified are the opinions regarding the segregation of the copper and tin alloys and also how complicated are its combinations. Certain retardations in the cooling curve of the copper and tin alloy were observed by Professor Roberts-Austen and Mr. Stanfield, and rather strengthened the view of Stead that in alloys which have more copper than is sufficient to made $SnCu$ may be mixtures of molecules of

that composition, with other molecules, containing a larger atomic proportion of copper.

But since such segregation of chemical combinations are influenced greatly by external agencies, it is not surprising to find contradictions regarding their composition even in the statements of reliable investigators.

The conditions influencing segregation apart from the composition are temperature, duration of the liquid state, the size of the casting, mode of stirring and perhaps other influences not yet understood.

Liquation may take place not only with alloy cooled from the liquid state, but also in the alloy which is carefully heated to the melting point of the most fusible alloy. I recently discovered a very interesting example of liquation occurring under the latter circumstances. It occurred in a driving-box of an engine on the Chicago & Great Western Railway. The alloy in question was one such as is used for bearing purposes, and contained according to analysis:

Copper	77·05
Tin	11·75
Lead	10·82

This metal was cast into what is known as a "liner," which is simply a lining 1½ inches thick, to be placed inside of the driving-box of cast iron, serving in place of babbitt metal, which is used on bearings not carrying so great a load. Great trouble was experienced in getting the engine to run cool, and it was at last decided to remove the bronze liners for inspection. The cast iron driving-box contained a hole for some purpose (what that purpose being I do not know), and upon examination of the liner, it was found that the metal had been so heated by friction that it had actually melted and squeezed out on the sides of the axle and into the hole in the iron box. The piece which had squeezed into the hole was about ⅝ inch in diameter by 1¼ inches long. I at once noticed by its great hardness and peculiar color that its composition must be different from the remainder of the alloy contained in the liner. Instead of finding it an alloy largely made up of lead, as the writer had expected to find before trying its hardness, it gave the following analysis at its base:

Copper	76·20
Tin	22·06
Lead	1·80

While at top there was a little globule of metal which, of course, represented the first part of the alloy brought to the state of fusion, which gave an analysis confirming Charpy in his analysis of the eutectic, which this clearly represented.

Copper	74·06
Tin	23·22 (by difference)
Lead	1·92

Although this alloy contained lead, it appears to replace only the tin, as the eutectic of copper and tin according to Charpy is about 74 copper and 26 tin. Another peculiar feature of the mixture was that it was exceedingly hard to break up with nitric acid, thus also pointing to the existence of a definite compound.

It appears to me that this accidental mode of isolating the eutectic in alloys suggests an easy method for their separation, that is to heat the alloy under pressure, allowing some crevice or hole in the piston into which the eutectic alloy may find its way. The writer intends making some further investigation on these lines.

That this isolated alloy is a true eutectic was further evidenced by its structure under the microscope.

Owing to the segregation of alloys and of iron and steel, which may also be considered as alloys of iron with sulphur, carbon, etc., and the consequent lack of homogeneity due to the complexity of influences governing this condition, it would be exceedingly hard, if not impossible to designate any particular structural appearance as a standard by which to gauge all others of similar composition. It appears to me that microscopic examination can at best be but a science built upon comparisons when based on standard methods as suggested by Mr. Outerbridge and should go hand in hand with chemical analysis.

Structure (as I have said before) is affected not only by temperature of pouring, rate of cooling, or in other words, heat treatment, but also by the size of casting, and method

and time of etching, etc., and for this reason I agree with Mr. Outerbridge in his statements regarding the necessity of standard methods.

I recognized these facts in my study of bearing alloys of copper, tin and lead, the results of which I gave in a paper which I read before this Section in May. My specimens were cut from the center of bars 1⅞ inches diameter by 6 inches long, into which size bars all the compared alloys were cast, being careful to have all the conditions as nearly alike as possible, manner of ramming, sand, venting of moulds, temperature of pouring, rate of cooling, time and manner of etching, etc.

Should the micro-examination become a practical technical mode of testing metals, it can be made so only by the use of standard methods, and it but remains to further the suggestion of Mr. Outerbridge on this point by the establishment of such standards.

MR. OUTERBRIDGE:—In summing up this interesting discussion of my paper, read at the last meeting of the Section, entitled "A Study of the Micro-structure of Bronzes," I wish to say that I am gratified to hear such unanimous expressions of agreement, coming from experienced workers in this field of investigation, upon the two principal suggestions contained in the paper, viz.: the desirability of the adoption of uniform methods of preparing specimens for the microscope, and of fixing upon standard sizes of test pieces. This, of course, does not mean that the investigator must confine himself to specified methods of treatment or to special sizes of specimens, but whenever such standard methods and sizes shall have been adopted by micro-metallurgists, the effects of variations of conditions upon the micro-structure of metals can be better understood and more readily explained.

After deciding in 1895 to again take up this microscopic work (after a lapse of over fifteen years), I procured copies of nearly all of the papers which have been published in the proceedings of various metallurgical societies bearing upon the subject, and also corresponded with some of the leading experts in Europe and in this country. I now have upon

the table several interesting letters received in reply to the inquiries.

These queries referred particularly to treatment of cast iron specimens, but the principles and precautions to be observed, are much the same whatever metal may be under examination.

Mr. Thomas Andrews, of Sheffield, whose work in the micro-study of steel and iron is well known, says: "I consider that there need be no doubt as to the accuracy of microscopic observations if properly conducted. It is always best to work with direct light and down through the objective (the objective glass thus becoming its own condenser). Reflected light will give you a false idea of the structure, owing to reflection from crystal facets." This I have found to be quite true in my experience and I have, therefore, adopted the vertical illumination, using oblique light only for special work, and where it is desired to obtain certain effects.

The objective which I use is similar to that employed by Professor Martens, and devised by Mr. Natchet, of Paris, for the use of the International Commission on the Meter; it contains a small prism in the objective tube set opposite an opening or window in the side of the tube at the angle of total reflection. By focusing a beam of light upon the prism through the opening in the tube, the light is projected down through the objective upon the specimen, illuminating the field brilliantly. By closing the shutter the vertical light is cut off and the specimen may then be illuminated by a side light; this is a very convenient arrangement.

Mr. J. E. Stead, of Middlesborough, Eng., says: "I think it would be advisable to polish such metal sections (referring to cast iron) upon pitch; as is done by Professor Martens."

I am also indebted to Mr. J. E. Keeley, of this city—an enthusiastic microscopist whose skill in preparing thin sections of minerals and other specimens is known far and wide—for valuable information pertaining to the subject.

It should, of course, be understood that some of the specimens photographed and illustrated in this paper have been intentionally "over-etched" for the purpose of showing the effect of such treatment.

While listening to the debates this evening my attention has been called by Mr. Webster to the fact that one of the subjects to be discussed by the International Committee on Testing Technical Materials, is that which we have here advocated; a paper having been announced in the program to be read by Mr. Albert Sauveur, of Boston, editor of the *Metallographist.*

CHEMICAL SECTION.

Stated Meeting, November 15, 1898.

[ABSTRACT.]

AGRICULTURE IN THE HAWAIIAN ISLANDS.

By Dr. Harvey W. Wiley,
Chief Chemist of the U. S. Department of Agriculture.

DESCRIPTION OF THE HAWAIIAN ISLANDS.*

The island of Hawaii, which gives the name to the group, is the largest of the series, embracing about 4,210 square miles of surface.

The island of Hawaii is more than five times as large as the largest of the other members of the group. The three most important islands after Hawaii, together with their areas, are as follows: Maua, 760 square miles; Oahu, 600 square miles; and Kauai, 590 square miles. The total area of the four large islands of the group is 3,110,000 acres. The other islands of any agricultural importance are as follows: Molokai, 270 square miles; Lanai, 150 square miles; Niihau, 97 square miles; and Kahoolawe, 63 square miles. The total area of the islands where agriculture is possible is 6,740 square miles. There are hundreds of other islands connected with the group, but they are mostly barren rocks, and at present have no agricultural significance, with the possible exception of those where birds collect in great numbers, and where the carcasses of birds, as well as the eggs which they deposit, are valuable for fertilizing purposes.

*The lecture was illustrated with stereoptic photographs of the landscapes and crops of the Islands.

The whole territory embraced by the Hawaiian Islands is included between longitude 154° 40′ and 160° 30′ west, and latitude 22° 16′ and 18° 55′ north. The extreme northern limit of the islands is therefore a little south of Key West, but, owing to the prevalence of the northeast trade-winds, the climate of Hawaii is probably the most grateful of any tropical climate in the world. The temperature at Honolulu rarely rises above 90°, nor does it fall below 54°. A case of sunstroke has never been known on the islands. White men can work in the open air and upon the farm in all parts of the islands, and this is not possible in other tropical countries.

The prevailing winds are the northeast trades. These blow for about nine months of the year. The islands possess a healthy climate. There are no virulent fevers such as are encountered on the western coast of Africa and in the West India islands. The island of Hawaii has been formed as the result of the action of four great volcanoes which are now extinct. The present active crater of Kilauea is evidently of too recent formation to have played any important part in the formation of the island. By the successive eruptions of the old volcanoes, and the cooling of the lava thrown out, mountains of lava have been formed by the four chief craters of the following respective heights: 13,805, 13,675, 8,275 and 5,505 feet. These peaks lie at an average distance of about thirty miles each from the other. It is evident that at first the spaces between the volcanoes were covered by the sea, but by the gradual degradation and overflow of the lavas these valleys have been filled up, and now in some places lie as high as 3,000 feet above the sea level.

From a geological study of the volcanoes it is evident that as they grew higher they opened lateral craters, due to the pressure upon the top of the crater. It is due to these lateral craters, largely, as well as to disintegration of the lava thrown out from the central one, that the intermediate spaces between the volcanic centers were filled. One of these lateral craters was developed from Maunaloa in 1868, when a stream of lava poured down

to the sea, making the water very hot to a distance of more than a mile from the shore, and killing all living things in contact with it. Dr. Maxwell observes that "in the space of a day's ride he noticed no less than eighty-nine of these lateral cones, and observed mounds covered by forests on the mountain slopes which suggested many more." Each one of those in its day and measure was a center of eruptive force. Lava in some form came from their throats, and fumes of acidulated steam escaped from fissures in the lavas in their localities, leaving marks of their action of disintegration which are not difficult to distinguish. This distribution of centers of eruptive action gives to the valleys dividing the great cones the true character of vast volcanic plains."

CHARACTER OF HAWAIIAN SOILS.

The typical soils of the Hawaiian Islands have been carefully studied by Dr. Walter Maxwell, formerly one of my assistants in the Chemical Division of the Department of Agriculture, and for some years past the director of the agricultural experiment station which has been founded by the planters of the islands.

From a study of the geology of the Hawaiian group it is evident that these islands are entirely of volcanic origin. Professor Dana says in regard to them, "The Hawaiian Island group is a sample of a line of great volcanic mountains. Fifteen volcanoes of the first class have existed at different times and been in action along the line." The group of islands therefore represents that portion of the great mass of matter due to volcanic action which is projected above the water level. Doubtless these islands are connected by ridges of volcanic matter which perhaps have never been above the surface.

The character of the original rocks composing the islands is therefore evidently that of lava in general. The rock formations are not sedimentary, but have resulted from the cooling of the lavas which have been projected from the volcanoes. This at least is true as far as the surface of the mountains is concerned. The great up-

lift forming the ridge probably was due in part to the ordinary causes producing mountain ranges, namely, the cooling and shrinking of the earth's crust. For agricultural purposes, however, the lavas are the only rocks which are to be considered, since it is from the decomposition of these lavas that the soils of the islands have been formed. The lavas have resulted chiefly from the fusion of rocks of basaltic nature, and hence the composition of the original lavas is such as would be produced by the fusion of basalt. The differences between the lavas and basalt would simply be those due to igneous action on fused basalt exposed to the air. The Hawaiian lavas resemble in their chemical constitution the basalts existing in the United States. A comparison of the analyses of a great number of lavas with a great number of American basalts is given in the following table:

Materials.	Analyses.	SiO_2.	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hawaiian Lavas	18	47.90	18.23	13.36	8.99	6.05	2.20	1.50
American Basalts	20	49.15	15.66	9.50	8.29	7.90	2.84	1.90

In the above table the analyses of lavas were made by Dr. Maxwell and his assistants, and of basalts by Prof. F. W. Clarke, of the United States Geological Survey, and his assistants.

FORMATION OF SOILS FROM LAVAS.

The formation of soils from lavas takes place under practically the same conditions which attend the weathering of ordinary rocks in the formation of common soils. All rocks, when exposed to the chemical and physical action of the forces which are found on the surface of the earth, suffer disintegration. Some kinds of rocks, of course, disintegrate much more rapidly than others, but all are affected. Soil, from an agricultural point of view, is the *débris* of rocks mixed with decayed organic matter. The forces which act upon rocks and lavas are many. Some of the more important ones only are mentioned here.

First of all may be considered the merely physical attrition. The beating of the rain, the eroding action of running water, the friction of the wind, and the grinding of particles of dust projected against the rocks, all tend to the same end, viz., the reduction of the rocks to fine particles.

The action of bacteria is also helpful to the disintegration of rocks. Even in localities in high mountains, where it would be supposed that bacteria did not exist, it has been found that fragments of rock are permeated to a greater or less depth with these organisms. In the exercise of their vital functions the particles of rock in contact with them become eroded, and are gradually rendered easy of degradation by other forces. Especially are the nitrifying bacteria active in erosion of this kind, since whenever they exercise their true vital function nitric acid results, and this acid acts rapidly upon most rocks in effecting decomposition. Even on rocks which seem almost bare, certain mosses and lichens are found to grow, and the vital activity of these vegetable growths rapidly affect the texture of the rock. It has been repeatedly shown that rocks, especially carbonates, when in contact with the rootlets of plants, suffer solution in all parts of contact. The growth of mosses and lichens in like manner disintegrates the rock and renders the processes of comminution easy. In the decay of organic matter, especially under the action of organisms, large quantities of acids are formed, which are carried into the rocks by the rains and help to dissolve them. The action of nitric acid has already been referred to. The action of carbonic acid which results from the oxidation of organic matter, is also powerful in effecting the disintegration of rocks. When the processes of soil formation have once started and small quantities of rock *débris* are formed, the growth of larger plants and the existence of terrestrial worms and insects help a still more rapid disintegration. In colder countries and on mountain peaks, where the temperature at times falls below freezing, the expansive force of water passing into the form of ice often helps to split up the rocks into smaller fragments. Inasmuch as many of the rocks are formed in conditions where metallic compounds tend to be

reduced to a metallic state or to a lower degree of oxidation, it is found that the oxygen of the air itself is a powerful disintegrating agent. It is carried into the exposed rocks either in the air itself or by water, and in oxidizing the lower to a higher oxid, or metals to the condition of oxids, powerful disintegrating influences are exerted. It is under these and similar influences that the lavas which have flowed out over the surface of the Hawaiian group have gradually been converted into soil.

In the regions of active volcanoes water has acted in a more powerful way, because it is forced into all the crevices by the steam rising from the volcanic action. The heavy rains, which often occur in those vicinities, fall into the craters of the volcanoes, and reappear as steam. It is probable, also, that subterranean passages admit water to the regions of great heat whence the lavas come, and the water thus admitted is converted at once into steam, and finds egress through the crater of the volcano and through all the crevices communicating therewith. In many parts of the islands this action of steam on the exuded lavas may still be seen.

The general nature of the various craters in their original form may be surmised by a study of one of more recent origin. The crater of Kilauea is 3,972 feet above the sea level. The area enclosed within this crater is 2,650 acres. This was doubtless in the not very far remote past a lake of liquid fire. The actual area, however, which is covered by melted lava at the present time is not more than 50 acres. Throughout the whole area of the crater, however, volcanic evidences may be seen. It is stated by Dr. Maxwell, who has made a careful study of this locality, that in the morning before sunrise, when the temperature is low, a large part of the floor of the crater is concealed by condensing steam which issues from fissures and fractures in the lava which have been produced by partial cooling. In some instances the condensing steam shows an acid reaction to litmus paper, and in a few instances the steam was found to be extremely acid. Over the areas covered with steam it was noticed that there were deposits of materials which

would be brought up through the fissures, and wherever this acid steam came into contact with the surface, evidences of rapid solution were seen. In one case, where a quantity of the steam was condensed and preserved for analysis, it was found to contain 4·92 per cent. of sulfuric acid. This steam contained no chlorin, showing that the sea water does not have ingress to the sources of volcanic activity. In the opinion of Dr. Maxwell, the action of this acidulated steam is one of the most important of the factors concerned in the disintegration of the lavas in the islands. In order to determine the effect of this action alone, as separate from that of surface forces, Dr. Maxwell removed the overlying slabs of lava and secured blocks from below which had never been exposed to surface forces, but only to the action of the acidulated steam mentioned above. At the time of taking the specimens the blocks were so hot that the hand could not touch them. Two of the larger specimens were found partially studded with crystals of sulfur. Where the steam has eaten out cavities in the blocks they were found partly filled with crystals of gypsum and alum. Over the surface and within the blocks iron was found oxidized and collected in pockets of red ochre, while the silica was separated into distinct masses of so-called yellow ochre. The process of decomposition was found to continue after the blocks were removed to the laboratory, so that the processes could be studied as they were taking place.

TYPICAL SOILS DERIVED FROM THE DECAY OF LAVA.

Two general types of soils are recognized as the resultant of the decomposition of the lavas in the Hawaiian Islands. These are distinguished at once by their color, and the two types are known as the "dark red soils" and the "yellow soils." This distinction in color, however, does not always serve to define the types of soils themselves, as both the chemical analysis and the character of the crops produced show that the soils of the yellow color sometimes belong to the red type and the soils of red color to the yellow type. It must not be understood from the names given to the typical soils that all the soils of the islands can be readily

grouped by their appearance into two classes. Between these definite types may be found all gradations of color, and a gradual merging of one type into another. In general in the islands the red soils are considered the more fertile, but, as intimated above, this is not always the case.

The dark red soils appear to have come, as a rule, from the lavas which were more or less free-flowing at the time of their ejection, and which have undergone slow disintegration, and where the rainfall has not been abundant. These soils usually are rather deep, in some places extending to a depth of three or four feet without any marked change of texture or color. The red color is so deep as to be appropriately designated "blood red." In many places where these soils have been formed large blocks of lava remain undecomposed, and are scattered over the surface of the soil in much the same way that the rounded boulders are found as the result of glacial action. Great expense is often necessary to remove these boulders in order to prepare the surface for cultivation. It is evident that this coloration of the soil is due chiefly to the oxidation of the iron contained in the original basaltic lavas from which the soils were formed. In the oxidation of the iron the first step is doubtless its conversion into ferric oxid. If this disintegration takes place at high temperatures, and in the presence of a minimum amount of water, the ferric oxid is practically free from hydrate and the color is a deep red. If, however, the oxidation takes place in the presence of an abundant supply of water, ferric hydrate may be formed, varying in color from red to yellow. It is evident that the temperature at which ferric oxid alone would be formed in the presence of steam must be rather high. It has been demonstrated by experiment that at a temperature of 200° F. in the atmosphere, ferric oxid is formed directly and no ferric hydrate is produced. It is evident, therefore, that the yellow soils, the other typical variety, have been formed in conditions of oxidation favoring a production of ferric hydrate. This is rendered the more certain from the fact that when these yellow soils are heated, and the combined water which they contain is driven off, they assume at once a red color.

Nearly allied to the dark red soils which have just been described may be mentioned the light red or crimson soils. These are essentially of the same typical character as the dark red soils, but contain a larger proportion of organic matter and a smaller quantity of lime.

YELLOW AND LIGHT RED SOILS.

The yellow and light red soils have evidently been derived chiefly, not from normal lavas, as was the case with the dark red soils, but from lavas which at the time of their ejection have been subjected to some sudden change which altered to some extent their nature. Lateral or tufa cones, as has already been remarked, are found in all parts of the islands, and the soils which have been derived from these—that is, the tufa soils—are consequently found over large areas. The tufa lavas are evidently the result of the expiring activities of large craters where the ejective force is not sufficient to drive the lavas entirely to the top of the cone, but only through the lateral fissures. The yellow soils therefore evidently have arisen chiefly from the decay of the masses of tufa lava. These originally were composed of mixed colors with very distinct shades, but by the action of water and wind and cultivation, the colors have been gradually mixed until the soils have assumed the yellow tint which gives them their characteristic name.

SEDIMENTARY SOILS.

In addition to the typical soils formed *in situ* which have been mentioned above, it is evident that sedimentary soils must be found in the valleys and other places in the islands where the original soils have been subjected to any considerable degree of translation. The sedimentary soils are usually found at low levels, and have resulted chiefly from the heavy rains in the mountains carrying the soil particles down and depositing them in the valleys. Some of the most fertile plantations of the islands are located on sedimentary soils. In some cases evidences are seen that these soils were at one time subjected to the action of the sea, showing that there have been considerable changes in level since the soil formation commenced on the islands.

DISTRIBUTION OF RAINFALL.

The rainfall in the Hawaiian Islands is extremely uneven and unevenly distributed. At Sprecklesville and Lahaina, on the island of Maui, the mean annual rainfall is only about 20 inches. Around the district of Pepeekeo the annual rainfall amounts to about 150 inches. At Olaa, on the island of Hawaii, on the windward side and at an elevation of about 2,000 feet, the rainfall for the years 1894–5 was 177 inches, while at Kailua, on the leeward side and nearer to the sea, it was only 51 inches during the same period.

RELATIVE FERTILITY OF THE SOILS.

As has already been mentioned, the dark red or blood-red soils, as a rule, are more fertile than the light red or yellow type. The sedimentary soils are almost equal in fertility to the dark red variety. The average period of cultivation of the chief agricultural regions of the islands, so far as sugar making is concerned, is twenty years. It is only about sixty years since any sugar at all was grown in the Hawaiian Islands for sale, although sugar-cane had been grown in a small way for domestic consumption for a much longer period. It was not until 1880 that any great advance was made in extending the sugar crop of the islands. In 1880 the total amount of sugar produced was only 30,000 tons. At the present time the annual production is about 250,000 tons. The productivity of the soils of the different types is clearly set forth in the following table, showing an accurate measurement of the average crop per year produced on more than 80,000 acres of land for a period of three years. The estimates were made only upon those areas upon which the typical soils were well marked.

Types of Soils.	Approximate Number of Acres.	Yield of Sugar Per Acre.
		Pounds.
Dark red soils	30,000	10,411
Yellow and light red soils	32,000	6,291
Sedimentary soils	20,000	10,301

The average number of crops of cane secured is one in two years. Although the actual time of the growing of a single crop may not be much over eighteen months, the other six months must be allowed for the time of preparing the land, planting, etc. From the above it is seen that there is very little difference in the yield of sugar obtained from the dark red and the sedimentary soils, while the yield from the yellow and light red soils is only a little over half of the other two. The character of the cane grown on the yellow or light red soils, however, is higher, the canes being richer and the juices expressed therefrom being purer. It requires, therefore, a less number of tons of cane grown on the yellow or light red soils to produce a ton of sugar than from the others. This is shown in the following table:

Soils.	Tons of Cane Per Acre.	Purity of the Cane Juice	Tons of Sugar Per Acre.	Tons of Cane to 1 Ton of Sugar.
		Per Cent.		
Sedimentary	47 80	84·2	5·11	9·1
Yellow or light red	23·60	90·5	3·08	8·1

COMPARISON OF HAWAIIAN AND AMERICAN (CONTINENTAL) SOILS.

It is interesting to compare the soils of the islands with those of the United States. In the very first place we notice the great difference in the origin of the soils. As has already been stated, the soils of the islands are essentially the products of the disintegration of basaltic lavas. The soils of the continent, on the contrary, are the product of the disintegration of limestones and granites. In addition to this, a large portion of the continent of North America occupied by the United States is covered by drift; that is, soil which has been deposited during the Glacial Age. This drift soil has in many cases been brought from remote localities, and in other cases has resulted from the grinding of the rocks in the leveling of the hills and filling up of the valleys due to glacial action. On the American continent, therefore, we find a great variety of soils, while on the

Hawaiian Islands, the soil is essentially of a single origin. A large number of analyses of typical American continental soils has been combined in the following table to get the average figures. In comparison with these are two columns of average data obtained from the analysis of a large number of Hawaiian soils of two types, viz., lowland and upland. The relative proportions of the different ingredients in the soils are shown in the table.

Ingredients.	American (continental).	American Lowlands.	Hawaiian Uplands.
Organic and combined water	5·18	16·80	23·30
Silica (insoluble)	69·02	10·29	10·67
" (soluble)	7·39	13·39	9·90
Titanic oxid	—	5·07	5·19
Phosphoric acid	0·34	0·72	0·87
Sulfuric acid	0·07	0·18	0·13
Carbonic acid	0·04	0·20	0·03
Iron peroxid	12·56	25·15	26·17
Alumina		23·54	20·06
Lime	0·79	0·85	0·64
Magnesia	0·73	1·35	0·95
Manganese peroxid	0·27	0·12	0·15
Potash	1·53	0·65	0·71
Soda	2·11	1·34	1·28

The most striking difference in the comparison above noted is shown in the quantity of insoluble silica. American soils are made up chiefly of sand in some form of combination or as pure silica. The table shows that altogether more than 76 per cent. of our continental soils consist of silica, of which nearly 70 per cent. is insoluble and a little over 7 per cent. soluble. In striking contrast with this are the data for the Hawaiian soils, showing for the lowland type a little over 23 per cent. of silica, and for the upland nearly 20 per cent. of silica. In striking contrast, too, are the relative proportions of soluble and insoluble silica in the two soils. In the American continental soil the insoluble is almost ten times the soluble, while in the Hawaiian soils the soluble and insoluble silica exist in almost equal quantities. The silica of the

American continental soils is largely replaced by iron and alumina in the Hawaiian soils. In the latter almost 50 per cent. of the total weight of the soil consists of iron and alumina existing in about equal proportions, while in the American continental soils only about eight per cent. of the total weight is composed of iron and alumina. Hawaiian soils may therefore be regarded as iron and alumina soils, and American continental soils as silicious in their composition. As is justly observed by Dr. Maxwell, the two kinds of soil are wholly different in their nature, and therefore the conclusions from an agricultural point of view which are derived from the study of one set of these soils cannot be applied with any degree of confidence to the other. The acidic elements in American soils are largely in excess, while in Hawaiian soils the basic elements preponderate.

One important consideration is derived from a comparative study of the two soils, viz., that plants are capable of adapting themselves to types of soils radically different, provided the plant food which these soils contain is accessible. In regard to the actual plant food which is present, it may be noticed that the phosphoric acid in the Hawaiian soils is about double that in the American continental soils. Potash, on the other hand, in Hawaiian soils is less than half that in the American continental type. In organic matter, on the other hand, the Hawaiian soils have the advantage, containing from three to four times as much organic matter and combined water as are found in typical American soils.

The Hawaiian soils are essentially new; in fact, the processes of soil formation are still rapidly going on. The American continental soils, on the other hand, are old, geologically considered—as old as those of the continent of Europe or of Asia.

ZONES OF AGRICULTURAL ACTIVITY.

For the purposes of agricultural consideration the Hawaiian Islands may be divided into four zones.

The first zone comprises that portion of the land beginning at the sea level and rising to an altitude of about 1,500

feet. All of this soil which is sufficiently decomposed and of proper contour and accessible to water is suited to the growth of sugar-cane, and the sugar-cane area comprises practically the lands situated between the limits of the altitude mentioned. In some rare cases sugar-cane is grown very successfully at a higher altitude, even up to 1,900 feet, but these cases are very exceptional. About one-half of the total area under cultivation in sugar-cane is artificially irrigated; the other half of the area depends upon the natural rainfall for its moisture. The character of the sugar cane grown in the Hawaiian group is probably better than that grown in any other quarter of the earth. The tonnage per acre is very high, and the juices of the cane very rich in sugar and very pure. Yields of 8 tons of sugar per acre have been secured, and an average of 4 to 5 tons per acre is counted upon in favorable years. The limit of cultivation of sugar-cane, aside from altitude, is determined by the degree of decomposition of the soil, the contour of its surface and the supply of water, the latter being the most important factor. The practical absence of running streams on the islands renders it necessary to collect the water artificially, either by ditches on the mountain sides to collect the surface drainage during times of storm, or by wells from which water is pumped to a sufficient altitude to secure the irrigation. It is evident, therefore, that the process of irrigation is expensive, and the quantity of water available is limited.

The second zone of agricultural activity comprises those areas suitable to cultivation lying at an altitude of from 1,500 to 3,000 feet. This zone is peculiarly suited to the culture of coffee, which has lately been undertaken in a systematic way on the islands. The coffee produced on the islands is now chiefly grown on Hawaii, and from the name of the district where the coffee is cultivated it is known as Kona coffee. The coffee produced is remarkably valuable, being esteemed of a finer quality than the best Mocha or Java. While the quantity of coffee produced is not yet very great, in fact, not enough to become a commercial factor, yet where it has been exposed for sale in San Francisco it has brought a higher price by about three cents per

pound than the finest coffees on the market. Many advantages to coffee culture are presented in the Hawaiian group In the first place, at the altitude mentioned, viz., 1,500 to 3,000 feet, it is found that artificial shading of the trees is not usually necessary. This, as is well known in tropical countries, especially in Nicaragua and Guatemala, is a very important factor in coffee growth. In the first attempt at growing coffee in the Hawaiian group it was thought to be necessary to secure artificial shade by planting trees of rapid growth and exuberant foliage. The coffee grown under these conditions has not been of as good quality as that grown without any shading other than that afforded by the trees themselves. In the second place, owing to the higher altitude, the precipitation in the coffee zone is sufficient to secure the growth of the trees without irrigation. Were it necessary to practice irrigation for the growth of the trees, it would be impossible to expect any large extension of coffee growing in the islands, since all the available water is now employed, practically, for the growth of sugar-cane, which is more profitable than that of coffee.

In the coffee zone are grown with considerable success the vegetables and small fruits, and even grains, necessary to the sustenance of the farmers. There are many places, also, in which cinchona, camphor and rubber trees grow with exuberance.

The zone in which vegetables, small fruits and grains grow may be called the third agricultural zone, although it overlaps in almost every place the zone suited to the growth of coffee. So these two zones, viz., that in which the coffee grows and that suited to the growth of vegetables, fruits and grains, may be considered together. The importance of the proximity of the vegetable zone to the coffee growers is at once apparent without further illustration. It requires several years to bring a coffee grove into bearing. Meanwhile the owners and workers of the grove must live. If they were compelled to purchase all their fruits, vegetables and other foods, the cost of bringing a coffee grove into bearing would be greatly increased. Therefore, it is seen that the proximity of the

zone where ordinary human foods can be produced in sufficient abundance is of the highest significance in considering the development of the coffee groves of the islands.

The fourth zone, from an agricultural point of view, occupies altitudes of from 3,000 to 5,000 feet. At these altitudes, wherever the contour of the surface is sufficiently smooth and the lava rocks sufficiently decayed, is found fine pasturage, where beef cattle and other domestic grazing animals flourish. It is not generally known that on these plateaus practically all the meat which is consumed in the Hawaiian Islands is produced. It is evident that these grazing lands can be made more generally effective by introducing modern methods of stock raising, so that the supply of domestic meat can be greatly increased. From an agricultural point of view that country is destined to the greatest prosperity which has the most fertile soil, the most favorable climate, the greatest variety of productions and the best markets. In all of these respects the Hawaiian Islands are most favorably situated, and it is evident that under the beneficent influence of American control, or as a part of the great American nation, they are destined to reach a state of evolution which is only limited by the areas which can possibly be brought into cultivation.

PRINCIPAL CROPS.

The chief agricultural product of the Hawaiian Islands is sugar. From what has been said it is seen that the sugar-cane grows in the greatest exuberance in the dark red soils and in the sedimentary soils near the coast. There is, perhaps, no other quarter of the globe where so large a quantity of sugar can be produced per acre as in the Hawaiian Islands. The possible crop of sugar, however, is limited by two conditions: (1) the small area of land which is suitable for sugar culture; and (2) the supply of water. In those portions of the islands where the annual rainfall is less than 35 inches, it is necessary to practice irrigation. Unfortunately the excess of water which falls on one side of the islands, where the rainfall is sometimes as high as 170 inches, cannot be utilized on the parts of the islands where

the rainfall is deficient. The greatest economy, therefore, must be practiced in the use of the water, and the greatest technical skill displayed in constructing reservoirs for holding the excess which is precipitated until such time as it may be needed by the crop. It is evident that all of the land suited to agriculture cannot be devoted to sugar growing, since there is a certain limit of appropriation which must not be passed. Vegetables and fruits must be grown on the islands, since it is cheaper to produce them than it would be to import them. In addition to these, the rice and taro plants must also find a place. From a careful study of the areas which can still be brought under culture, and the quantity of water which may be made available for irrigation, it seems to me that the maximum production of sugar in the islands may be conservatively placed at 500,000 tons, a little over double the annual amount now produced. In the agricultural possibilities of the islands, therefore, it is not wise to count upon a future maximum product of more than the amount just mentioned.

It is further evident that the production of sugar is not an agricultural industry in which a poor man could profitably engage, except as a renter. The cost of bringing the lands under irrigation, and the great cost of sugar factories would prevent the poor farmer from engaging in the industry on his own account. Large capital controlling large interests is necessary to produce sugar at a minimum cost.

The planting and cultivation of sugar-cane in the islands are conducted in general as in other cane-producing countries. There are, however, some peculiar conditions connected with the industry in the islands which deserve mention. In localities where the supply of water is not abundant, as, for instance, at Sprecklesville, it has been found that it is more profitable to plant the cane freshly for each crop than to depend upon the rattoons. If the water be placed upon the rattoons after the harvesting of the crop in order to preserve their vitality the growing cane must be neglected, and if the water be used for the growing cane the rattoons must be left to die. For this reason, in the localities mentioned it is customary in nearly all cases to plant anew for each crop.

In other localities, where the supply of water is abundant, either under irrigation or by natural rainfall, the crops are left from ten to twenty years without replanting, the rattoon canes producing abundantly, and having a rich and pure juice.

As in other countries, the rattoon canes contain more fiber and woody matter than the canes grown directly from the first planting. Usually, in planting, the small canes which are left in the field and the tops of the good canes are planted. Sometimes young rattoons are cut and planted. As little as possible of the rich and mature cane is used for seed purposes.

In the older fields artificial fertilizing is carried on extensively. All kinds of fertilizers are used, some of them blindly and others with due regard for the needs of the crop. At Spreckelsville, especially, the soil is deficient in nitrogen, and nitrogenous fertilizers are about the only ones employed. For this purpose fish scrap from Alaska is used. The principal point in Alaska where this fish scrap is prepared is Killisnoo.

The manufacturing season begins at various times. In fact there is no period of the year when it is not possible to make sugar. Generally, however, the season lasts from the 1st of January to the 1st of June.

RICE AND TARO.

Rice and taro are two crops which are grown under water. The white citizens of the islands who are not native born do not well endure the work in rice and taro fields. In the islands the labor of the production of rice is left almost exclusively to the Chinese and Japanese, while the production of taro is conducted by the natives.

Rice culture is so familiar that it is not necessary to describe it in detail. It can only be practiced on level areas where large quantities of water can be secured for flooding. There is, however, an upland variety of rice which is grown with considerable success in the islands. This rice does not require submersion, but grows after the manner of an ordinary cereal. Its yield per acre, however, and its quality,

are not considered equal to the rice of the lowlands grown under water. Nevertheless the rice industry is one which is capable of a considerable degree of expansion, and the product of the rice fields finds a large market at home.

The taro is a plant which is known botanically as the "Colocasia antiquorum." It is also a plant which is grown under water. The taro gardens are very small in extent, but the quantity of food which they produce is something enormous. It has been estimated that a taro patch 40 feet square, containing 1,600 square feet, will produce enough food to sustain one person for a year. The taro is a plant which resembles, in many of its properties, the sweet cassava, which grows in such abundance in this country, in Florida. The starch and other nutritive properties, however, are stored in a bulbous root, and not in roots which extend from a central stem in every direction, as is the case with the cassava plant. The taro, like the cassava, contains an acrid principle, probably, as is the case with cassava, hydrocyanic acid, which renders it unsuitable for eating in the raw or fresh state. On baking or boiling, this acrid principle, being volatile, is expelled and the baked mass is entirely free of the objectionable taste and styptic qualities of the fresh material.

In the preparation of taro the bulbous roots are cleaned and baked, usually in ovens built in the earth, the heat being furnished by hot stones, previously heated by burning wood. The baked or boiled root is beaten to a paste in a wooden trough with a pestle made of a rounded piece of lava. It is then mixed with water and allowed to stand for two or three days until fermentation has taken place. Water is added until the paste is of a given degree of consistency, and the material, after thus fermented and mixed with water, is the great national diet of the natives, and is known as "poy." Poy is made either of the one-, two- or three-finger variety, the thickest paste being eaten with one finger, the next thinner variety being eaten with two, and the thinnest paste of all being eaten with three fingers. Poy is eaten by the family out of a common bowl, into which the fingers are stuck, when with a skillful whirling

movement the poy is made to adhere to the finger and is then carried to the mouth and sucked off. Poy, being a starchy material, is very fattening, and on account of the ease with which it is produced and prepared, it is the food which is preferred by the native population. The whites also, after a time, learn to like it. In the valleys where the taro is grown, the patches planted are so constructed as to receive the water from a running stream. The bottom of the pond is made of fertile clay or soil, and the native islander, by working only an hour or two a day, can keep his taro patch free of weeds. The growth of taro will probably continue, indefinitely, to be one of the great agricultural industries of the islands, supplying the natives with their chief quantity of food.

COFFEE CULTURE.

The coffee industry in the islands has, in the last few years, grown very rapidly, hundreds of thousands of young trees having been planted, and many of them are just coming into bearing. Coffee trees are first sprouted in a nursery, and after attaining a growth of one or two years are transplanted to the coffee groves. As has already been intimated, it has not been found necessary, in the Hawaiian Islands, to protect the coffee plants in the groves by planting other trees. The moderate temperatures at which the coffee groves are found do not prove injurious to the plants. This is a great advantage which the Hawaiian groves have over those in the hot tropical countries, where the planting of shade trees is an absolute necessity.

Coffee trees, when properly grown, begin to bear in the fifth or sixth year, and by the seventh year, in favorable conditions, they ought to produce enough coffee to pay for their care and the interest and other fixed charges on the plantation. After the seventh year the coffee trees should yield a profit. Unfortunately for the coffee growers, the rapid decline in price which coffee has undergone in the last few years has prevented many of the owners of orchards from making the profit which they expected.

FRUITS AND VEGETABLES.

In the uplands fruits and vegetables grow with good success in parts of all the islands. It is evident that as the population of the islands increases the production of fruits and vegetables will acquire a greater agricultural significance. Strawberries, raspberries and other small fruits are grown with excellent results, and in some localities even apples and other fruits of that class can be produced. Bananas and cocoanuts are easily grown, and afford a considerable degree of encouragement for the agriculture of the future. Already large quantities of bananas have been exported from the islands, chiefly to the San Francisco markets. Pineapples grow in great abundance, and are sources of profit to the small grower. Cattle and pigs flourish in many parts of the islands, and pigs especially are found in almost every portion, as their flesh is much prized, not only by the natives, but also by the white settlers of foreign birth. There are many cattle in the hill countries where there is good grazing and yet where the land is too rough for cultivation. At these high altitudes the grazing of cattle for the meat market will probably prove profitable.

HARDSHIPS FOR THE POOR IMMIGRANT.

I have set forth above, briefly, and yet I hope clearly, the conditions which attend the practice of agriculture in the Hawaiian Islands. It is well that the intending immigrant of small means consider carefully all the hardships which he may expect before he finally decides to migrate to our far-off Pacific possessions. If he go as a mere laborer, he will have to begin in a climate to which he is not accustomed, although it is an agreeable one, and to come in competition with the cheap labor which has already been established in that locality by the importations from China and Japan. The Hawaiian Islands are, therefore, a place which, it seems to me, the American laborer should avoid, unless he can go under contract with some of the large agricultural interests, like the large sugar factories of the islands.

For the small farmer there is more encouragement, as the

growth of pigs and small fruits in the uplands, coffee on the middle hills or uplands and cattle in the grazing lands still higher, form some of the inducements for profitable labor. Nevertheless, the small farmer must act with great caution and not cast his fortunes hastily in a land so far away.

For the capitalist there are yet large opportunities of successful investment in the islands. There is still a large amount of sugar land which can be brought under cultivation, but this requires a heavy outlay of capital. There are few areas now unoccupied in sugar production in the Hawaiian Islands where the land could be properly cleared, smoothed and irrigated for less than $100 an acre. Add to this the original cost and the fixed charges of the investment, and it is seen that large capital is necessary to push forward the sugar industry in the islands. Still, I think that of the three classes of probable immigrants mentioned, viz., the laborer, the small farmer and the capitalist, the advantage certainly lies with the latter.

We have seen how crops, which for countless centuries have grown on other soils, adapt themselves without harm to the new environment to which they are subjected in the islands. Here the future years will see the garden spot of the great American people, led by fate to extend their liberties and their institutions to the islands of the Pacific. The climate will attract alike the invalid, the eager traveler, the weary seeker after rest and the immigrant. Nowhere else will the sun's rays be found so grateful, the flowers so eternal, the breezes so balmy. Men and plants thrive equally well in these dreamy regions, children of the sun and sea, where neither the heats of summer wither nor the snows of winter chill. May we not hope that the flag, emblem of our progress and our power, shall also take root in this new soil, and the blessings of liberty and progress be ever secure beneath its folds.

ELECTRICAL SECTION.

Stated Meeting, November 8, 1898.

THE STATUS OF ELECTRICAL INVENTION.

By William A. Rosenbaum.

(*Concluded from vol. cxlvi, p. 456.*)

Some of the early arc lamps gave excellent results when working singly on a circuit, but as commercial lighting was impossible on this plan, something different was required. In commercial lighting, the series connected lamps were the first used, and they were made possible by one of the great discoveries in arc lamp regulation, the "shunt" circuit. This provided for the use of two magnets, one in the main circuit for pulling the arc, and the other in the shunt circuit for keeping it of uniform length. This is known as the "differential" lamp, and has been varied in a multitude of ways, but in principle remains in use to-day. The means whereby the attractive force of the magnets is utilized, has also been variously modified. The clutch, being an important element, received special attention. One of the earliest and simplest forms was known as the "ring clutch," consisting of a metal ring encircling the upper carbon or its rod, resting at one edge on a support, while its opposite edge was raised and lowered by the differential action of the magnets. An increase of the angle would cause the ring to grip the rod, enabling the magnets to lift it, while a decrease of the angle would release and allow the rod to fall. The ring clutch is seldom seen now, but its successor is usually an eccentric device of a more complex nature.

Following the successful introduction of the series lamp came a demand for long burning lamps. This was met at first, though not successfully, by changing the shape and dimensions of the carbon electrodes into plates, disks and various other forms affording more body, but the best form

and the one which enjoyed the most extended use was the double carbon lamp, in which the carbons were consumed in succession. For lamps burning on constant potential circuits, the most recent and almost universally adopted plan for long burning is the "enclosed arc" lamp, capable of continuing in operation for 100 to 150 hours. This increased life of the carbons is due to the fact that the arc is enclosed in a chamber from which the atmosphere is excluded, combustion of the carbons being thereby retarded. Alternating current lamps are now in use on constant potential circuits, but their construction does not materially differ, inventively considered, from the continuous current lamps. Focusing lamps, wherein the arc is maintained at a fixed point in space, are now in common use where it is desired to project a strong beam of light. The fixity of the arc is accomplished by feeding both carbons by mechanism operating on the same general plan as that of the series connected lamps.

Taking up incandescent lighting at the beginning of its commercial existence, and bearing in mind that this paper is treating of "invention," we scarcely find anything of importance to note beyond the production of the one form of lamp which has been in use since its origin in 1879, and the system of distribution by which it is most economically operated. It is true that many processes and methods of preparing the lamp filament, of making the bulbs, of clamping the filaments to the leading in wires, and of exhausting and sealing the bulbs, have been invented; likewise improvements in the sockets and keys, but these do not rise to the dignity of "important" inventions as herein considered. With the invention of the "three-wire" system of distribution in 1882 we can safely admit that the art of incandescent electric lighting, as we know it to-day, was substantially perfected.

Experiments have been made during the past two or three years on a system of lighting which, according to the claim of the inventor, more nearly approaches daylight than any other known system of illumination. This is the vacuum tube lighting, a modification of the Geisler tube experiment,

wherein the light is created by interrupting a high tension circuit in a high vacuum. This invention, while interesting from a scientific standpoint, has not yet come into commercial use.

Under the head of electric lighting we may properly refer to the beautiful discovery of X-rays by Professor Roentgen. Notwithstanding the fact that this discovery was made known less than three years ago, it has already entered extensively into the service of man. The number of prominent inventions has not been great, attention having been directed more generally to improving the apparatus at first used. The devices for producing the rays consist of a source of high potential electricity, such as an induction coil, a high frequency circuit breaker, a condenser for accumulating and rapidly discharging electric energy, a Crookes tube and a source of current such as a battery. The devices for determining the presence of the rays are either a sensitized photographic plate or a screen covered with crystals capable of becoming fluorescent under the action of the rays. The screen itself is not of so recent origin as the contrivance in which it is mounted for convenience, and which is known as the fluoroscope, the invention of Mr. Edison.

In entering upon the subject of dynamo electric machinery and electric motors we have no difficulty in placing the credit of their origin to Michael Faraday at the date of 1831. It would be a pleasure to dwell upon the beautiful experiments of this early investigator, but time presses and we must proceed to a brief review of the discovery and invention of the salient elements.

Faraday's dynamo consisted of a copper disk rotating between the poles of a permanent magnet, with brushes located respectively at the axis and periphery of the disk.

Within a few months machines on the principle of magneto-induction had been devised, and alternating currents were produced in bobbins, which shortly after was followed by the invention of the commutator for straightening out these currents. From this time on, numerous improvements appeared by Ritchie, Saxton, Clarke, Jacobi and others, until 1848 when another "milestone" was fixed

in the road of development, in the discovery that the main current could be directed around the field magnet and produce a self-exciting machine. Contemporaneously the laminated armature was invented and this, shortly after, was followed by the machine in which neither field magnet nor armature rotated, the periodic variations in the magnetic field being produced by a rotating body of soft iron; 1856 marks the origin of the Siemens shuttle wound armature, and Dr. Werner Siemens is by some given the credit of the invention of machines having electro-magnets only, in contradistinction to the prior machines using all or part permanent magnets. The shunt wound machine was the invention of Wheatstone, and dates from 1867. The question of obtaining continuous currents with less fluctuation, brought out the Paccinotti ring armature, and this paved the way for the very important invention of the Gramme ring. In 1878 Brush introduced his famous machine embodying the principle of open coil working, and about this time Hopkinson showed how greatly the performance of a dynamo was improved by improving and making more compact its magnetic circuit. In 1881 Marcel Deprez suggested that a constant potential current ought to be obtained by providing the field magnets with a second coil supplied with uniform current from an independent source. This was almost immediately followed by the adoption of the compound winding for obtaining self-regulation.

The discovery that the action of a dynamo is the simple converse of that of the motor, and that the same machine can serve either function, appears to have been gradually made. The earliest electric motors in which the principle of attraction by an electro-magnet was applied, were those of Henry, in 1831 and of Dal Negro in 1832, and these were followed by the machines of Ritchie, Jacobi and Davenport. The idea of transmitting power from one dynamo as a generator to another used as a motor, is ascribed to Fontaine and Gramme in 1873. In 1882 Ayrton and Perry made the important discovery of the automatic regulation of motors to run at constant speed, by methods the converse of those adopted for making dynamos self-regulating.

We cannot leave the subject without brief reference to the development of the polyphase motor. The birth of this piece of machinery, which is now so rapidly coming into use, is accredited to Mr. Walter Bailey, in 1879. Bailey's machine had four electro-magnets, 90° apart, facing a copper disk; the magnetism was caused to shift progressively from pole to pole, thus producing eddy currents, which by their reaction gave the disk a mechanical motion in the direction of the progression of the poles. In 1883 Deprez laid down the important theorem as to the production of a true rotating magnetic field by the combination of two alternating currents, having as their difference of phase a quarter period. In 1893, at the World's Fair, Professor Ferraris exhibited a machine embodying two pairs of electro-magnets, having a common yoke and a pivoted central body. Two alternating currents differing in phase were passed through the two-field circuits, causing the central body to rotate. Amongst the American pioneers of polyphase investigation was Chas. S. Bradley whose work dates early in 1887. He first used a Gramme ring having four radial connectors, led off at four symmetrical points to four rings, and thus obtained two alternating currents differing 90° in phase. This machine could be used as a motor.

The work done by Mr. Tesla in the four years following 1887 was in itself sufficient to have established a rotary field motor upon a solid basis. A distinguishing feature of his motor was the absence of all sliding contacts.

Other prominent workers in this field were, Wenstrom, Dobrowolsky, Brown and Hutin & Leblanc.

In taking up the subject of chemical generation of electricity, it is not with the intention of compiling anything like a complete list and description of all the combinations proposed or actually used as primary batteries. A large proportion of them are more curious than useful, and many have scarcely the merit of novelty. It is, therefore, the intention to refer briefly, as heretofore, only to those discoveries in this field which have marked the beginnings of new classes of batteries with perhaps some reference to special novelties that have not gone extensively into use.

The Voltaic battery, as the name implies, was a discovery of Volta, who noticed the twitching of the frog's legs when touched simultaneously by connected pieces of copper and iron. From this he worked out the Voltaic pile, consisting of alternating layers of two different kinds of metal, separated by bits of moistened cloth, which was the first apparatus ever designed for the production of a continuous flow of electricity.

The first constant battery was the Daniell, invented in 1836. In this cell a copper plate is immersed in a solution of copper sulphate to prevent the disengaging of hydrogen upon it. The mechanical construction of the cell involves a porous cup, inside of which is a copper element and outside a zinc element; the zinc is immersed in a solution of zinc sulphate, while the copper is in a solution of copper sulphate contained in the porous cup.

The gravity battery is a simple modification of the Daniell, designed to avoid the use of the porous cup. The zinc and copper sulphates are separated by their difference in density.

The Grove battery consists of a cylinder of zinc, immersed in dilute sulphuric acid, and a thin plate of platinum in strong nitric acid contained in a porous cup.

Following the Grove cell came the Bunson, a modification in which a block of baked carbon was substituted for platinum.

The application of bichromates as depolarizers followed shortly after the Bunson cell. The Fuller bichromate cell provides for the continuous amalgamation of the zinc, insuring minimum local action and more constant current. The Partz acid gravity battery represents an application of the gravity principle to an acid depolarizer. The copper oxide battery, invented by Lalande and Chaperon, is an example of the use of solid depolarizers, in closed circuit batteries. Mr. Edison devised a modification of this battery, known as the Edison-Lalande, in which the copper oxide is employed in the form of a compressed slab, which, with its connecting copper support, serves also as a negative plate. The chloride of silver was a very early form of

cell, its elements are zinc and silver, the zinc chloride furnishing the depolarizer, is cast upon the silver element.

The batteries so far spoken of, are of the closed circuit type, and are distinguished with one exception by the use of liquid depolarizers. We now come to those batteries in which solid depolarizers are used, and which are known as the open circuit batteries, of which the Leclanche cell stands at the head of the list. The depolarizer of the Leclanche cell is manganese dioxide; it is used in the form of granules mixed with broken carbon to increase the conductivity, the negative plate is carbon packed in a porous cup with the depolarizer, while the positive element is a zinc rod and the exciting liquid salammoniac. The prism form of Leclanche cell was devised to dispense with the porous cup, but more satisfaction has been obtained from the cell in which the carbon element, in the form of a cup, is made to serve the purpose of the earthen porous cup.

The oldest exponent of batteries in which no depolarizer is used is the Smee battery. The positive plate is zinc and the negative silver with roughened surfaces, the function of which is to mechanically dislodge the hydrogen as fast as it is released at the negative plate. The Law battery is another type of this class in which reliance is placed upon large carbon surfaces to effect depolarization mechanically.

A large portion of the more recent open circuit batteries appearing, are the so-called "dry" type which contain the excitant in the form of a paste, the composition of which in most cases, is secret.

Under the head of chemical generation, we may refer to the production of electricity direct from coal, of which the battery of Dr. W. W. Jacques is the most recent and promising apparatus operating upon this principle.

About the earliest discovery in this direction was that of Becquerel, who noticed in 1885 that he could produce a current of electricity by burning carbon in contact with an electrolyte capable of supplying it with oxygen.

Considerably later than this an experiment of Jablochkoff demonstrated that a current of electricity could be generated by the action upon carbon of a solid electrolyte in a state of fusion.

Later than this, in 1882, it was suggested by J. Hubert Davies that a current of air be used as a "depolarizer." This is one of the leading features of the Jacques battery. A year later than Davies, Mr. Alexander Melville Clark conceived the idea of "fixing the oxygen of the air in a substance susceptible of forming a liquid combination, and then expending this oxygen to produce electricity by the oxidation of a suitable substance (generally carbon), and lastly reoxidizing by the oxygen of the air, the substance which serves as the vehicle." Clark's work does not appear to have met with much success.

The inventions so far mentioned, while lacking in importance from a commercial standpoint, serve to mark the beginnings of this interesting method of obtaining electricity, and in fact, with the unimportant efforts of a few other investigators, constitute the state of the art prior to the invention of Dr. Jacques, heretofore mentioned.

Dr. Jacques demonstrated the practicability of his electric furnace by a series of experiments conducted in 1891.

His theory of the basis of his invention was that "if oxygen, whether pure or diluted, as in air, be caused to combine with carbon or carbonaceous material, not directly as in the case of combustion, but through an intervening electrolyte, the potential energy of the carbon may be converted directly into electrical energy instead of into heat." The practical apparatus includes means for creating an air blast and a furnace for heating the cell.

The Jacques theory of the operation of the cell has been recently criticised, and it is now quite generally accepted that the theory of the cell, as originally enunciated, is incorrect in several particulars. However, the important point is not so much the theory of operation whereby a new result is produced, as the fact of the result itself. The Jacques battery has undoubtedly been accepted as a prominent "milestone" that will direct a future line of development.

The origin of the secondary battery can be traced back to within a few years of Volta's discovery of the primary battery, but its importance was not appreciated at a very

early date. In 1842 Grove constructed his gas battery, from which a current could be obtained by the uniting of hydrogen and oxygen, which were first produced by the electrolytic decomposition of water. But it remained for Gaston Planté, in 1860, to commercially appreciate the invention he had discovered. The Planté battery contained two simple lead elements in a weak solution of sulphuric acid. The distinguishing feature of the battery was the process of "forming," to which it was subjected, in order to produce the active material on the plates. This forming process consisted in charging and discharging the battery a number of times to gradually produce a layer of peroxide on the positive plates and spungy lead on the negative plates. Following Planté's invention came a large number of improvements thereon, some of which were directed to increasing the surfaces of the lead plates, while others were designed to quicken the process of forming. The next important departure, however, was made by Faure and Brush, about 1880. They conceived the idea of accelerating the formation of the plates by applying to their surfaces a layer of chemically prepared oxide of lead, made into a thick paste, and then converting it into active material by the action of an electric current. After the passage of the current, it was found that the oxide on the positive plates was converted into peroxide of lead, while the salt on the negative plate had been reduced to porous lead. As in the case of the Planté cell, this improvement by Faure and Brush was followed by a large number of inventions, designed to improve the mechanical construction of the cell, one of the most important developments having been invented by Sellon, and which consisted in shaping cells or chambers in the plate, for the reception of the lead paste.

The lead-zinc storage cell was another type to be early developed. In this cell one of the plates was an ordinary Planté or Faure peroxide plate, while the other was a thin sheet of lead, on which a thick layer of electrolized zinc had been deposited. In this battery many of the difficulties arising from local action were eliminated; the origin of this cell is commonly attributed to Reynier.

Another type of storage cell which has been given considerable attention and practical use, is the zinc-copper alkaline cell, in which the positive element is pure copper, produced usually by electrolytic reduction from a solution of copper oxide, and compressed into blocks or plates; the negative element is zinc, while the solution is either potash or sulphuric acid.

The liquid accumulator is a curious form of storage cell, in which the electrical energy appears to be, not in the electrodes, but in the electrolyte, and in which the electrodes, which may be of metal or carbon, are removed after the charging process, and others substituted for the discharge.

In closing the subject of secondary batteries, the third method of applying the active material to the plates, in lead batteries, should be spoken of. Besides Planté's method of electrically "forming" and Faure's method of mechanically applying the active material in the form of a paste, there is a third method, which consists in depositing or plating the active material into the crevices of the plate.

To sift out and distinguish the leading inventions from the mass of work that has been done in order to bring the electric railway to its present standard of commercial success, is no easy task, the difficulty being in determining what was invention and what was mere mechanical or engineering skill. Notwithstanding the fact that a very large percentage of the street railways in this country have changed their motive power to electricity, and nearly every new road now installed utilizes electric power, it is interesting to know that the whole art of electric traction is based upon a very few leading inventions.

The very first appearance of the electric railway in the history of the world is attributed to the little circular model built by Thos. Davenport, a Green Mountain village blacksmith, in 1837. This model consisted of a car carrying a motor whose field magnet was fixed, and whose revolving armature was connected to the axle by bevel gear. The invention, like many others that followed it through the years 1850, 1855 and 1860, failed, largely because of the lack

of a suitable source of electricity. This pioneer railway, as well as those of Hall, Page and other early workers, derived its propelling current from primary batteries carried on the car. The advent of the successful dynamo electric generator marked the beginning of practical railway development. Among the pioneers who took advantage of this may be mentioned Geo. F. Greene and Stephen D. Field, who contemporaneously invented the plan of connecting the electro-motor on the car with a stationary dynamo by means of conductors. This occurred just prior to 1880.

In 1882 Jos. R. Finney exhibited an electric street car, an overhead wire, a trolley fitted with grooved wheels running on this wire as a track, and connected with the car by a flexible conducting cord. The year 1884 marks the first instance of an electric car in regular operation on a street railway track in the United States, as also the reduction to practice of the conduit system, wherein the conductors are mounted upon insulators in a conduit, and connection made therewith by means of a plough extending through the slot in the conduit.

The invention of the car controller on a vehicle receiving its propelling current from a stationary source is credited by some to Greene. The invention of the speed-controller, by commutating the field of the motor or motors and the controlling box for accomplishing this, is another important invention in the art, and while the carbon brush is used on many other machines besides on traction motors, it may be mentioned here as one of the important factors in railway development.

Still another important invention is the Sprague method of mounting the motor on spring supports, to protect the gearing and allow for slight changes of relative position of the armature shaft and axle.

One of the most important developments in the electric railway and, indeed, about the last, was the slow-speed motor, the production of which, although due largely to the skill of the designer, was the subject of an invention originally. No practical machine of this sort appeared until the summer of 1890, when the Wenstrom Company, of Balti-

more, brought out a very efficient and well-designed motor that possessed this valuable property of slow speed. This machine was also among the pioneers in the so-called "iron-clad" type, where the magnetic circuit completely shuts in the armature and field coils. The speed of this machine was about 400 revolutions per minute, which permitted of its armature being geared directly to the car axle without the intermediate countershaft that had been the subject of frequent objurations from every electrical man who had been in the business long enough to have gearing give out.

We have now briefly traced the leading inventions in the main branches of the science of which we are treating, and if time permitted we might go beyond and look into the history of the secondary branches of the science including electrical measuring, electro-plating, electro-therapy, electric heating and so forth, but as the purpose of the paper has been fulfilled, perhaps the writer may be pardoned if he adds a thought or two suggested by a consideration of one of the most important inventions mentioned in the course of the paper, to wit: wireless telegraphy.

Why should the "wireless" characteristic be confined to the telegraph? If the coherer responds to interruptions of the electrical waves coming through space, why cannot the density of the waves be varied and the coherer made to respond to such variations and make wireless telephony possible? Why, indeed, should we not have wireless electric lighting when Mr. Tesla has already divided the number of wires, apparently necessary, by two? And why should we not have wireless electric railroading and wireless power transmission with selective receiving apparatus for all, preventing interference? Finally, why should not the name of the discoverer of the "Hertzian waves" become the greatest among the great names identified with the history of electricity. While these questions must be left to the future for solution, the rapidity of progress in modern times in electrical research justifies the belief that ere long all of them shall have been determined in the affirmative; indeed, almost coincidently with the penning of these lines, the

announcement is made that Mr. Tesla has succeeded in transmitting large amounts of electric current through the rarefied strata of air surrounding the earth.

THE FRANKLIN INSTITUTE.

Stated Meeting, November 16, 1898.

A PROCESS OF FIRE-PROOFING WOOD TO BE USED FOR THE WOODWORK OF WAR VESSELS.

By C. J. Hexamer, Ph. D.

Since a long time chemists, engineers and others have experimented to find a suitable process of rendering combustible materials non-combustible. My own labors have extended over a number of years. In a paper "On the Prevention of Fires in Theatres," read before the Institute on June 21, 1882, I called attention to what had been accomplished to make scenery in theatres fire-proof, and gave expression to my ideas on the subject, based upon a series of laboratory experiments. A special committee of the Franklin Institute was subsequently appointed for further investigation, with myself as chairman, and, at the request of my fellow-members, I conducted a number of additional tests, the results of which were embodied in a report accepted at a stated meeting of the Institute, April 18, 1883. After the sad catastrophe, occasioned by the burning of the Central Theatre, at Philadelphia, I was requested by the Secretary of the Institute to prepare a paper, which I read at the stated meeting held May 18, 1892, in which I submitted, in a casual way, the results of further experiments—giving a *résumé* of the United States patents on "fire-proofing," and pointed out the prerequisite conditions necessary to make theatre scenery incombustible. I desired to show that anyone, with a little practice, could protect scenery without having recourse to patented processes, for some of which, I was informed by theatre proprietors, exorbitant prices were being demanded. The problem of rendering scenery incombustible has, generally

speaking, been solved. All the above papers were printed in the *Journal of the Franklin Institute*, and are readily accessible. I will not, therefore, take up valuable time by repeating anything there stated.

When our recent war with Spain demonstrated *ad rem* the necessity of rendering the woodwork of war vessels incombustible, I again set to work on the problem of fire-proofing wood, not with a view of pecuniary gain, but to render my country a service.

The Secretary of the Navy has appointed a "Board for Investigating the Matter of Fire-proof Wood for Use in Naval Vessels," and early in October of this year the chemist of the Board applied to me for advice. I wrote him that my experiments had convinced me that satisfactory results could only be obtained by a process of injection and precipitation in the fibers of the wood; and later he wrote me that he had now arrived at the same conclusions. I state these facts to dispel any wrong impressions that may have arisen, for I am not appearing before you to-night to exploit a commercial enterprise.

The problem to be solved is not an easy one, and in order that the results I obtained might be corroborated by an unbiased authority—for investigators are often deceived into anticipating the favorable results they are seeking—I submitted my conclusions to the professor of chemistry at the Philadelphia High School, Dr. H. F. Keller, whose experiments have verified my results.

A process for fire-proofing the wood of war vessels must possess the following qualifications: (1) The material deposited in the fiber of the wood must render it thoroughly incombustible; (2) moisture or water, whether fresh or salt, must not affect the materials in the wood, in other words, they must be insoluble; (3) the impregnating matter must adhere permanently to the fiber so that it cannot be shaken out by any amount of wear or jarring; (4) glycerine or like hygroscopic substances, used in conjunction with other chemicals to render theatre scenery incombustible, must not be used, as they would tend to rot the wood; (5) the entire mass, not the surface only, must be equally well pro-

tected by the fire-resisting substance, because in battle the woodwork is broken and shattered, and external applications permeating the wood but a short distance, though valuable in ordinary buildings, would be useless for the former purpose.

Water is not only our cheapest solvent, but also the one universally obtainable, and therefore best suited to be used on a large scale. For this reason I concluded to employ a substance soluble in water in the primary saturating liquid, which, in turn, was to be rendered insoluble by precipitation in the fibers by an aqueous solution of another substance, forming with it an insoluble compound. Such a process, with ideal substances, would possess the additional advantage that the insoluble compound would be precipitated, as infinitesimal particles, into the very fibers of the wood, causing it to remain there permanently. No amount of jarring or vibration could shake it out, for, like a soluble dye-stuff made fast or insoluble by a mordant in textile fabrics, it would last as long as the fibers in which it is imbedded.

Injection into the fibers of the entire mass, and the precipitation there of an insoluble fire-resisting compound is, therefore, the desideratum.

The question naturally arises, how can a solution be forced into the innermost recesses of the fibers of thick masses of wood? I knew that the most reliable experimental work regarding the saturation of wood with solutions had been done in connection with various attempts to preserve it against rotting and the toredo or ship worm. Before, therefore, beginning to experiment blindly, I carefully studied what had been done in this direction; examining technical books and journals, Wagner's "Jahrbuecher," the reports of committees, boards of inquiry, state commissions, patent reports and processes in actual use.

As a result of my studies and experiments, I came to the conclusion that the best method for impregnating the entire mass of the wood was to subject it to the following process: In the first place, use only well-seasoned timber, thoroughly air-and kiln-dried,and worked approximately into the dimensions needed, or, better still, impregnate, whenever possible,

the finished articles. Then place the wood into a strong metal chamber, specially made for the purpose, capable of withstanding strong pressures, supplied with a lid that closes it hermetically. The receptacle is surrounded by a steam jacket, so that the temperature in it can be regulated at will. The interior of the chamber must be thoroughly dry before the wood is placed there. Let me caution you against steaming lumber before saturating it, a custom still prevalent in many creosoting works. The laborious tests of Drude have conclusively proved that steaming wood before impregnating it with solutions tends to lessen its absorptive powers, and that, therefore, it should be as dry as possible. The temperature in the receptacle is slowly increased above the boiling point of water, which is maintained until all the moisture in the wood has been expelled and the mass is equally heated throughout. The chamber is then hermetically sealed and the temperature in it is reduced to 60° C., and held there. The air in the receptacle is now extracted as quickly as possible by means of an air pump. The more complete the vacuum the better will be the ultimate results. Few persons have any idea of the amount of air contained in porous substances like wood. I certainly had not, until I began experimenting. After the air in the wood has been removed a solution of water glass of about three times its volume of water, previously heated to 60° C., is sprayed into the vacuum. This method of injection is used to remove the air in the solution. The solution must not be too dilute, but at the same time not so thick as to refuse to enter the finest tissues of the wood; in other words, it must be of such a consistency that after impregnation it is completely retained in the pores. It is almost needless to add that the final results depend on the completeness with which the moisture, sap and air have been removed from the wood before impregnation.

I will not weary you by recounting the lengthy list of materials employed as a primary impregnating fluid, only to return at last to the one with which I had started—soluble glass, one of the best known of fire-proofing materials, which possesses the additional advantage that it is cheap.

I might state here that for ordinary purposes a block of wood can be made fire-resisting by repeatedly soaking it in a water-glass solution, and, when dry, coating it with a mixture of the liquid and cement.

To return to the process, when the wood has become saturated with the solution at normal conditions, hydrostatic pressure of about ten atmospheres is applied, which is kept up for three hours; this drives the liquid through the mass. Numerous experiments made in Germany for the conservation of wood (see Mittheilungen des technologischen Gewerbemuseums. Abtheilung, Holz) have conclusively demonstrated that the "hydrostatic-pressure method" is the only one to be relied upon for forcing solutions to the innermost parts of a log.

The question now becomes what to use to precipitate insoluble silica from the solution of soluble glass, thereby forming an insoluble compound in the fibers? A dilute solution of hydrochloric acid was tried at first, but this affected the wood, and would in practice attack metal receptacles. Gaseous and liquefied carbonic acid were experimented with, also calcium chloride, until finally a solution of ammonium chloride, a very cheap substance, was used with excellent results. This produces in the very fibers of the wood a gelatinous precipitate of silica, most suitable for our purpose; salt, which is readily removed from parts near the surface by soaking in water, tending to preserve the wood in the interior; and ammonia gas, which goes off *per se*.

To apply this secondary liquid the water-glass solution is drawn from the receptacle, and the before-described process is repeated with the ammonium chloride solution. In practice it may be found advantageous to use a second receptacle, removing the wood from one to the other. The pressure should be applied gradually in the second treatment, so as not to force out the first solution. After the precipitation has been completed the wood is thrown into a stream of running water to dissolve and wash out the salt near the surface, and is then slowly dried.

It may be of interest to add that, as a secondary result

of my experiments—by using stronger solutions than are necessary for fire-proofing purposes—I had some beautiful specimens of petrifaction; and Dr. Keller so completely turned a piece of filter paper into stone, that it seemed to be a delicate film of some pure white silicious mineral, and no one could possibly have surmised what the substance originally was. It is, therefore, possible that this process can be utilized in the arts in the future to petrify organic substances.

It will probably be urged that my process is expensive; but in a case like this expense is not a factor. We cannot afford to take the risk of not having everything possible about a man-of-war—or for that matter of any ship—fire-proof, when upon that fact may depend a victory or a defeat of our navy. Nor is the expense as great as it at first appears; for the Government should attend to this work itself, and not leave it to contractors. In point of fact, I believe it will be found that the only considerable outlay necessary would be the first cost of the large air-tight receptacles. There are, no doubt, plenty of pumps on hand that could be utilized, the amount of labor required is trifling, the chemicals used are of the cheapest, and the plant can be located in a place where running water costs nothing. I therefore fail to see any possible reason why lives on ship should be endangered by fire in the future.

I beg leave to state, in conclusion, as my humble opinion, that everything on board of a ship can be made fire-proof. Some things, of course, must be excluded by necessity, such as food, fuel and ammunition.

OLD AND NEW METHODS APPLIED IN PLANNING PIPE-LINES AND PENSTOCKS.

By F. M. F. Cazin.

The author of the cited paper desires to substitute therein the last paragraph on page 291 by the following lines, and to state that the substitution will further facilitate a clear conception of the new method, but without in any way subjecting it to modification:

"It seems to be entirely superfluous to carry the demonstration any further. That which has been shown appears to be sufficient to convince us of the existence, in pipes of uniform width, of causes for loss of capacity of delivery, which causes, under the new method, find an intelligent explanation and at the same time an adequate remedy. And these causes may be specified as follows, namely:

"(1) The loss, attributed to *orifice of influx*, is caused by insufficiency of current-section for permitting more than a certain quantity of water to pass with the velocity due to the head between the level of orifice and the surface of supply. For a stated diameter of pipe the said quantity may be increased, by lowering the level of orifice, thus increasing the head above the same, and in consequence the velocity of inflow. Equivalent means for increase of quantity are extant in widening the orifice of influx, according to requirement of new method.

"(2) The loss, commonly attributed to *friction*, is caused by one of two other and real causes, or by either thereof, namely:

"*a*. The water falls in such quantity, as area of orifice and head above orifice will permit, and this quantity falls in its natural form with its naturally increasing velocities, leaving all the water in the pipe, which fills the space, not included in such natural form of flow, comparatively without motion, just so as if such excessive space were not enclosed in the pipe; or, *b*. The space in excess of the

natural requirement must be successively supplied with water, causing the water to fall with a larger transverse section, and, as the falling quantity is limited by the inlet, the fall proceeds with less velocity. Excess of space is beneficial only when uniformly provided for, and when in close adaptation to the form indicated by nature and disclosed by the modern method."

NOTES AND COMMENTS.

THE X-RAYS IN METALLOGRAPHY.

The latest application of the X-rays is to the study of metallic alloys. When the alloy is composed of two metals having different transparencies to the rays, radiographs taken of thin plates show the separation of the two during solidification. As an example, it is stated that an alloy of aluminum and gold shows on solidification the segregation of a definite compound of the two metals, which separates in well-defined crystals. W.

A NEW METHOD FOR HARD-FACED ARMOR.

A new method of producing a hard-faced armor plate of uniform composition has been devised by M. Werth, manager of a large iron and steel works in France. The inventor takes advantage of the fact that by suitably controlling the process of cooling it is possible to obtain some of the newer alloys of iron and steel with nickel, cobalt and manganese in either a hard, or a malleable, condition. He contends for a plate having the same chemical composition throughout, the hardening of the face being effected by tempering.

The following details of M. Werth's procedure are abstracted from the *Iron Age:*

Ordinary carbon steel in large masses cannot be tempered satisfactorily, but when alloyed with suitable proportions of nickel, cobalt or manganese it is possible to obtain the metal in a hard state by heating it up to a bright red and allowing it to cool in the air; whereas, if heated only to a dull red and cooled, the metal will be malleable and comparatively soft. The steel used by M. Werth is open-hearth metal, free from sulphur and phosphorus. It contains from 5 to 15 per cent. of nickel or cobalt, and from 2 to 12 per cent. of manganese; while within certain limits silicon, chromium or tungsten, may be present without interfering with the process of tempering. In its soft state such a steel has a tensile strength of 110,000 to 140,000 pounds per square inch, and a strip 1¼ inches thick can be bent without cracking round a radius equal to its thickness. After the plate is completed it is tempered by making it part of the side or bottom of a furnace. The face next the fire becomes heated to a bright red, while by means of water or air the temperature of the back face is kept down to 800° or 900° F. To insure good results the heating is effected very gradually, the plate being put into a cold furnace; and, by prefer-

ence, gas fuel is employed in the latter. Another method of effecting the heating which is, however, only applicable to flat plates, is to immerse their front faces in a bath of red-hot lead, the temperature of which is maintained very uniform. When ready the plate is removed from the furnace and cooled at the back, until the front face has sunk down to a temperature of 800° to 900° F., when no further attention is required, though, if warped, it can now be straightened before the cooling is finished. W.

A SUBSTITUTE FOR GALVANIZING IRON AND STEEL.

Wilder's patented process for coating steel and iron consists in the use of a bath composed of zinc, tin and aluminium. This mixture, it is claimed, produces a coating on iron and steel much superior to any now known, being so firmly adherent that the sheets will stand working after it has been applied, will resist corrosion, and can be heated red hot without injury. The coating is applied by the same method as galvanizing, *i. e.*, by dipping the cleansed sheets, etc., in the melted alloy. The most approved mixture is the following composition by weight: Zinc, 84 per cent.; tin, 14 per cent , lead, 1·5 per cent.; aluminium, 0·5 per cent. W.

ELECTROPLATING ON WOOD.

If a simple method of coating wood electrically with metallic deposits of silver or copper could be devised, there should be a considerable demand for such articles for ornamental parts of various articles of furniture, mouldings, picture frames, etc. Mr. C. F. Barnes describes, in the *Electrical World*, a method which, he believes, will meet the requirements. The operation is briefly as follows: The wooden article is first saturated with copper sulphate by immersing it in a solution of that substance; then removed and thoroughly dried. It is then exposed to the action of hydrogen sulphide gas, which converts the sulphate of copper to the sulphide—which is a conductor of electricity, and also insoluble in aqueous solutions. Then the article is lightly wrapped with fine copper wire and suspended in a solution of common salt at the cathode, and a current of some density is passed. The copper sulphide is thereby speedily reduced to metallic copper, by the reducing action of the cathode products. When the reduction is supposed to be completed, say in ten minutes, the article is transferred to an ordinary copper-plating bath where a coating of copper of any desired thickness may be formed upon the surface. The copper surface may be polished or varnished, and is very adherent. For silver, the process is modified by immersing the object, after preliminary coppering, in the silver-plating bath. W.

NEW METHOD OF WATERPROOFING PAPER.

The German journal *Neueste Erfindungen*, describes the following method of making a waterproof paper: The sheet is coated on both sides with a solution consisting of 1 part gelatine, 4 parts water and 1 part glycerine. When dry, the paper is immersed in a 10 per cent. solution of formalin. After this treatment, the paper is said to become impervious even to steam.

W.

RESTORING THE ILLUMINATING POWER OF INCANDESCENT LAMP MANTLES.

Neuesle Erfindungen contains an interesting account of an observation, made by Herr Franck, by which the illuminating power of the Welsbach mantles may be restored. The method was described by the author at one of the meetings of the Polytechnicher Verein in Berlin.

As is well known, the mantles decline in illuminating power after they have been in use for some time. This luminosity may be restored to a certain degree, by blowing out the mantle from the inside while they are burning, which can be accomplished with the aid of a small glass or paper tube. The President of the Society stated that he had personally tested the method and had found it effective, and, in consequence, recommendable. In order to facilitate the carrying out of the process, the German Incandescent Gaslight Company manufactures a tube, mounted in a rubber ball, which is very convenient for the purpose. W.

MANUFACTURE OF STEEL CASTINGS IN THE UNITED STATES.

Mr. Stewart Johnston read an instructive paper on this subject at the recent meeting of the American Foundrymen's Association. After giving a historical sketch of the growth and development of this branch of the metallurgic arts in the United States, and some useful hints respecting the difficulties encountered in practice and how to overcome them, he gives the following statement of the present state of the art:

"The uses to which steel castings are put are beyond enumeration, and are daily becoming more varied, although at the time of their introduction in the United States, in the seventies, their position in the commercial world was one of insignificance. Limited to a few lines, the production in first years did not annually exceed 200 tons. Steel castings now invade every field in metallurgy save the one occupied by the chilled iron roll when used for rolling finished steel, and for that purpose no steel cast substitute has ever been considered a dangerous rival. It is estimated that the annual production of steel castings in the United States is from 80,000 to 100,000 tons." W.

FIRE-HAZARD OF TALL BUILDINGS.

Cassier's Magazine calls attention in a recent impression to the practical impossibility, under present conditions, of checking a fire when it attacks the upper stories of a modern American "sky scraper," and refers to the recent destruction by fire of one of the so-called "fire-proof" office buildings in New York City as another illustration of many others that might be instanced of this fact. It is obvious that with the extravagant extension skyward of so many buildings in American cities, the difficulty of successfully protecting them against destruction by fire has very greatly increased.

On this point *Cassier's* quotes the opinion of Chief Bonner, of the New York Fire Department, to the effect that none of the modern "sky-scrapers" are fire-proof, and that once a fire gets a good start in one of the upper stories, nothing can be done but to let it burn. To fight a fire above a height of 125 feet, he holds to be utterly impossible. As the only practicable remedy for this

danger, he recommends that authority be given to the building department of the city to compel owners of buildings over six stories in height to provide their own fire-fighting apparatus in the form of interior standpipes and the necessary hose and other equipments.

No reliance can be placed, he holds, on the so-called fire-proof construction of walls and floors, since this has been over and over proved fallacious. W.

MAIZE OIL.—A VALUABLE PRODUCT FROM THE INDIAN CORN.

The following information from a recent Government publication may pave the way for the establishment of a profitable industry:

"In the manufacture of starch and glucose, and in some varieties of maize meal, the germ, which contains the larger percentage of oil, is extracted. From this germ a valuable oil is expressed, while the residue forms a food material as valuable in every respect as that derived by the expression of the oil from ordinary oily seeds. Maize oil is easily purified, and forms a light, amber-colored, perfectly transparent liquid, without rancidity and of a pleasant taste. It has been used to some extent as a salad oil, and doubtless will in the future be very greatly employed for that purpose. It can also be used for lubricating delicate machinery, has fine burning properties, and can be used as a lamp oil. The coarser and less pure oil makes a valuable soap. In general, it may be said that maize oil has a commercial value, gallon for gallon, quite equal to the oil derived from cotton seeds." W.

THE FUTURE OF ACETYLENE AS AN ILLUMINATING AGENT.

In a thoughtful editorial on this subject, the *Electrical World* advances the following views upon the role which acetylene may be expected to play as an illuminant in competition with gas and electricity:

"As a competitor in the illuminating field acetylene will probably be a greater rival of illuminating gas than of electric current, and it is possible that its success will be of more benefit than harm to the latter. It is the old story over again of one rival stimulating another in competition, and by means of improved service and reduced cost increasing the demand by an amount greater than its own supply. Illuminating gas, electric lighting and acetylene all have their own individual advantages which, to a certain extent, outline certain fields of application of each in which the others cannot compete. For vehicle lighting, including train lighting, and for gas distribution where but a small percentage is used for fuel, acetylene will probably show advantages over other forms of gas; while for combined heating and lighting service from one system, illuminating gas cannot be met by either acetylene or electric current, but for isolated plant service, theatre lighting and all cases where ease of control from a distance or convenience of ignition or adaptability to special decorative effects, are of any importance, the electric current has the advantage. It cannot be met by its competitors in the qualities of safety, neatness, cleanliness, convenience and elegance." W.

ALCOHOL FROM THE BY-PRODUCTS OF COKE MANUFACTURE.

London *Industries and Iron* gives the following technical item in its current notes:

"According to Herr P. Fritzsche, the gases of coke ovens are specially suitable for the recovery of alcohol. He has gone carefully into the matter, and, on reducing to alcohol the ethane contained in the issuing gas, he found a content of 1 to 1·8 per cent. by volume, and upon studying the speed with which sulphuric acid absorbs ethane, he concluded that the absorption process is perfectly practicable, the apparatus for ethane recovery from coke-oven gases being considerably smaller than that for benzol separation. Herr Fritzsche calculates that for the production of 26·5 gallons, equal to 176 pounds of alcohol, 107 pounds of ethyl sulphate, 771 6 pounds of concentrated sulphuric acid and 1,102 pounds of water are required.

"Apropos to the above item, it may be commented that the presence of ethane in the gases of the coke ovens has been known, and that the reaction with sulphuric acid is also not new. Herr Fritzsche's merit lies in pointing out that the quantity of ethane in the issuing gases of the ovens may be sufficient to make the problem of making it a source of alcohol a commercial possibility." W.

A TEXTILE FIBER FROM PEAT.

The English Board of Trade *Journal* refers to a recent report of the French Minister at Stockholm to the effect that the manufacture of textile products from peat fiber has been introduced in Sweden. The fibers, produced from peat by a mechanical process, it is said, can be mixed in the proportion of 75 per cent. with pure wool for the manufacture of yarn similar in appearance to woollen yarn. W.

ENGLISH RULES REGULATING THE USE OF PETROLEUM OILS.

In view of the inefficiency of the State and municipal laws regulating the indiscriminate sale of dangerous oils for household use, it may be of interest to note that, notwithstanding the fact that the laws already in force are much more stringent than ours, the British Parliament has deemed it necessary to appoint a Commission to revise the existing laws in the interest of the public safety. This Commission has just made a report embodying the following conclusions:

"That the present law not being adequate for public safety, should be amended in the following particulars:

"(1) To adopt a flash point of 100° Abel closed test, as the dividing line between petroleum oil and petroleum spirit.

"(2) Legislation to control the storage, transport and sale of petroleum generally and admixtures of the same with other substances, certain heavy oils being exempted.

"(3) To provide for an efficient system of testing.

"(4) To provide for adequate supervision and administration by local authorities.

"(5) That official inquiries be made into the causes of accidents arising from the storage, transport or use of inflammable liquids.

"(6) Statutory powers to enable the Secretary of State to issue orders affecting the manufacture and sale of lamps.

"(7) To spread information among the public as to the nature of petroleum and the management of petroleum lamps." W.

TECHNOLOGY OF ALUMINUM FROM A BRITISH STANDPOINT.

At the summer meeting of the Institution of Mechanical Engineers, held at Derby, Mr. E. Ristori gave the members an account of the present state of the aluminum industry in England, and in connection therewith made some interesting comments on the applications which the pure metal and its alloys had received. From these it appears that the British practice of manufacturing the metal differed in some important features from ours—notably in the use of a different form of furnace, and in the production of a crude metal which is afterwards brought up to high grade by a refining process. The details of this last would be extremely interesting, but none are given. Some useful data were given in reference to the technology of the metal, an abstract of which follows:

Mr. Ristori stated that aluminum could be forged hot or cold, and, in comparison with other metals, it ranks third in order for malleability and sixth for ductility. Sheets have been hammered as thin as $\frac{1}{20000}$ of an inch. In turning, the edge of the tool soon becomes blunt, and the cutting speed should be high. In its purest form aluminum is very soft and not of great service in those arts in which much rigidity and strength were required. One casting alloy having a specific gravity of 2·9 is now largely used, but its composition is still kept secret. It has been found to produce remarkably clean castings which required very little machining to finish up, and takes a high polish. Another alloy contains aluminum and a small proportion of copper The two alloys particularly recommended as among the best yet made are both ternary alloys, and next to the aluminum, tungsten is the leading ingredient in each. In one of them copper is present to a small extent, and in the other nickel, and both have given astonishing results as regards strength and elongation. Samples of rolled sheets or rods made of these alloys show as much as 20 to 22 tons tensile strength per square inch, with 5 to 10 per cent. elongation in 4 inches. Aluminum bronzes are undoubtedly superior in strength, and they are especially suitable for marine engineering. Mr. Ristori gave many illustrations of the uses of aluminum, and speaking broadly, he said that the metal or one of its light alloys should, to a large extent, replace copper, tin and nickel. Its use in shipbuilding is growing rapidly on account of its great saving in weight. In some cases pure aluminum is not strong enough alone, and it is thought better to use an alloy containing about 6 per cent. of copper. This possesses a tensile strength of 14 tons per square inch, but this material is absolutely untrustworthy in sea water, owing to the rapid corrosive action set up between the two ingredients. Unfortunately this comparative failure had materially discouraged the adoption of aluminum in shipbuilding, but, eventually, when further experiments have been carried out, there is no reason why a suitable alloy should not be adopted, which, when properly used and protected from direct contact with sea water, would resist corrosion as effectually as the majority of materials now employed. W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, December 21, 1898.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 21, 1898.

MR. H. R. HEYL in the chair.

Present, 85 members and visitors.

Additions to membership since last report, 38.

The resignation of Mr. Clayton W. Pike from the Committee on Science and the Arts was presented and accepted.

The following nominations were made in conformity with the By-Laws—to be voted for at the annual election to be held Wednesday, January 18, 1899:

For President	(to serve one year), ...	JOHN BIRKINBINE.
" *Vice-President*	(" three years), ...	CHAS. BULLOCK.
" *Secretary*	(" one year), ...	WM. H. WAHL.
" *Treasurer*	(" one year), ...	SAMUEL SARTAIN.
" *Auditor*	(" three years), ...	WM. H. GREENE.

For *Managers* (to serve three years).

THOS. P. CONARD,	ISAAC NORRIS, JR.,
JAMES M. DODGE,	STACY REEVES,
C. LELAND HARRISON,	FRANCIS SCHUMANN,
WASHINGTON JONES,	COLEMAN SELLERS.

For the *Committee on Science and the Arts* (to serve three years).

HUGO BILGRAM,	CHAS. JAMES,	E. ALEX. SCOTT,
FRANK P. BROWN,	ARTHUR KITSON,	COLEMAN SELLERS,
J. J. DEKINDER,	WILFRED LEWIS,	H. W. SPANGLER,
W. C. L. EGLIN,	EDGAR MARBURG,	WM. H. WAHL,*
A. M. GREENE, JR.,	EDWARD F. MOODY,	F. L. GARRISON,*
FRED. E. IVES,	C. J. REED,	W. N. JENNINGS.

To fill the unoccupied term of Clayton W. Pike, resigned, FRANCIS HEAD.

Capt. Joseph U. Crawford, Engineer of Branch Lines Pennsylvania Railroad Company, addressed the meeting on "An Engineer's Observations in Cuba. The speaker gave a *résumé* of observations made during a recent professional visit of several months, respecting the conditions at present existing on the Island, with especial reference to agricultural, industrial, engineering and transportation problems present and prospective.

Mr. Oberlin Smith, President of the Ferracute Machine Company, Bridgeton, N. J., by special request, repeated with some elaboration his communication lately given to the Mining and Metallurgical Section, describing a new

*Declined.

minting plant designed and constructed by the company for the Chinese Government. The speaker illustrated his theme by the exhibition of lantern projections of the machinery and of the coins (the latter by the megascope); and gave an interesting account of the tribulations experienced by the representative of the company in transporting the plant several thousand miles into the interior of China and erecting it.

Mr. Charles Day exhibited and gave a description of several forms of kites, including the Marvin-Hargrave box kite used by the U. S. Weather Bureau in making meteorological observations.

The Secretary, in discussing the subject, referred to the circumstance that some fifty or sixty years ago there was in existence in Philadelphia an active society called the "Philadelphia Kite Society," organized for the purpose of making use of the kite as an instrument in meteorological research. He mentioned the fact that Professor Espy, in his "Philosophy of Storms," made reference to the usefulness of the work of this society in determining the altitude of cumulus clouds. All traces of the records of this interesting organization, however, appeared to have been lost, as the most persistent inquiry had failed to reveal any clue as to their whereabouts.

The meeting passed a vote of thanks to the speakers of the evening.

The Secretary presented a communication from Dr. Joseph W. Richards, of Lehigh University, transmitting specimens of the salts of two alleged new chemical elements, "Cosmium" and "Neo-cosmium," described by Dr. Kosmann, of Charlottenburg.

The presumable new substances were separated from the rare earths, and are said to be of special value for incandescent lighting. The salts shown were cosmium nitrate and neo-cosmium nitrate.

Adjourned. WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held December 3, 1898.*]

PROF. L. F. RONDINELLA in the Chair.

The following subjects were considered:

Passed first reading:

Check Punch. Geo. O. Brosnaham, Jr., Pensacola, Fla.

Steam Trap. Antoine Heintz, Liège, Belgium.

The Omnimetre. Albert Sexton, Philadelphia.

The resignation of Mr. Clayton W. Pike was presented and accepted with the Committee's regrets. Ordered to be reported to the Institute.

W.

SECTIONS.

CHEMICAL SECTION.—*Stated Meeting*, December 20, 1898, Dr. Lee K. Frankel, President, in the chair. Dr. Henry Leffmann read a paper on "Digestive Ferments with Especial reference to the Effects of Food Preservatives."

Mr. Lyman F. Kebler read communications on "Bébées (a new yeast plant) and "Notes on Estimating Eucalyptol." The communications were freely discussed and referred for publication.

The following nominations were made for officers for the year 1899, viz.: President, Dr. Jos. W. Richards; Vice-Presidents, Dr. J. W. Williams and Lyman F. Kebler; Secretary, Waldemar Lee; Conservator, Dr. Wm. H. Wahl.

Special Meeting, December 6, 1898, Dr. Lee K. Frankel, in the chair. Prof. C. B. Cochran presented a paper on "The Detection of Foreign Fats in Butter," illustrated liberally with the aid of photo-micrographs.

Dr. Robert H. Bradbury addressed the meeting on "Reaction Velocity." Both communications were freely discussed and referred for publication.

ELECTRICAL SECTION.—*Stated Meeting*, December 13, 1898, President W. E. Harrington, in the chair.

Prof. Charles F. Marvin presented a communication on "The Kite as an Instrument in Meteorological Research." The paper was illustrated by the exhibition of a specimen of the Hargrave box-kite, as modified by the speaker, and of the automatic recording devices employed in meteorological work of this nature.

Prof. Arthur J. Rowland made a communication on "Commercial Photometers and Light Standards." The papers were referred for publication.

The following nominations for officers for 1899 were made, viz.: President, Prof. Geo. A. Hoadley, Prof. W. M. Stine; Vice-Presidents, G. U. G. Holman, S. B. Locke; Secretary, Geo. T. Eyanson; Conservator, Dr. Wahl.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, December 14, 1898, President A. E. Outerbridge, Jr., in the chair.

Prof. H. C. Mercer addressed the meeting on "Fresh Studies of Pioneer Tools," supplementing a former communication on the same subject. The speaker illustrated his remarks with the aid of lantern slides, and of numerous specimens of primitive tools used by the early settlers of Southeastern Pennsylvania. A Committee was appointed to report nominations for officers for the ensuing year.

MECHANICAL AND ENGINEERING SECTION.—*Special Meeting* for organization, December 15, 1898, Mr. James Christie was called to the chair, and made an address on the scope of the new Section, and the character of the work it was hoped to accomplish by its means.

Remarks appropriate to the purpose of the meeting were made by Dr. Coleman Sellers, Mr. Cyrus Chambers, Jr., Mr. Washington Jones, Mr. H. R. Heyl, Prof. Edgar Marburg, Mr. Coleman Sellers, Jr., Mr. S. L. Wiegand, and others.

A code of regulations, prepared by the Secretary, was read and adopted, and a Committee was appointed to report nominations for permanent officers.

The second Thursday of the month was chosen as the evening for holding the Stated Meetings of the Section. W.